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DEFORMITY

Posterior Multilevel Vertebral Osteotomy for Severe and Rigid Idiopathic and Nonidiopathic Kyphoscoliosis

A Further Experience With Minimum Two-Year Follow-Up

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Study Design. Prospective randomized study.

Objective. To evaluate the clinica! and radiologic outcome of posterior multilevel vertebral osteotomy (PMVO) in patients with severe kyphoscoliosis.

Summary of Background Data. Authors have developed and reported results of PMVO for correction of neuromuscular scoliosis. PMVO has advantages such as, posterior-only procedure which avoids risk to pulmonary complications and gives satisfactory correction. However, its effect in correcting severe scoliosis in presence of rigid kyphosis has not been reported.

Methods. Thirteen patients (7 idiopathic, 4 cerebral palsy, and 2 congenital scoliosis) with severe and rigid kyphoscoliosis were operated by posterior-only correction with pedicle screw fixation using PMVO. As per pathology, and associated severity of kyphosis little modification in the original technique was applied while correction and osteotomy. Neuromonitoring was applied in all patients during operation. The radiologic and clinical results were evaluated with an average follow-up of 42.9 ± 11 months. All postoperative complications were also noted during the follow-up period.

Results. Average number of osteotomy was 4.2 ± 0.8 (range, 3–5). Average preoperative Cobb angle, pelvic obliquity, thoracic kyphosis, and lumbar lordosis were 99.2° ± 29.6°, 8.6° ± 9°, 73.6° ± 56.9°, and −47.2° ± 63.2°, respectively, which improved after surgery to 44.7° ± 12.3°, 2.8° ± 2.9°, 45.3° ± 15.9°, and −47.7° ± 12.2°. All corrections were maintained at final follow-up. A 54.3% correction was achieved in coronal plane; and, full correction was achieved in sagital plane as thoracic kyphosis was restored within normal range. Average blood loss and operative time was 3015 ± 1213 mL 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. All pulmonary complications were due to associated thoracoplasty during which pleura was ruptured intraoperatively. Two patients had complication related with the implants; 1 screw breakage and other screw prominence. There was no neurologic injury intraoperatively on motor-evoked po- tentials (MEP) or clinically after surgery.

Conclusion. PMVO exhibited satisfactory clinical and radiologic results in patients with severe and rigid scoliosis associated with hyperkyphosis at minimum 2-year follow-up. It can be safely applied with modifications in original technique for complex congenital scoliosis with multilevel hemi or block vertebrae and idiopathic/nonidiopathic spinal deformities.

Key words: posterior multilevel vertebral osteotomy, severe kyphoscoliosis, correction, safe. **Spine 2011;36:1146–1153**

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Severe kyphoscoliosis is a deformity with fixed spinal vertebrae that does not allow traction, suspension, or side bending of the spine. The lack of a mobile spine frequently results in early truncal decompensation and a large compensatory curve, which may progress with time.[1] The physiologic and mechanical issues inherent in the kyphoscoliosis are still challenging. Surgery is the most common treatment at present. However, the surgical techniques for correcting the deformity are difficult and often challenging. Usually, vertebral column resection (VCR) is a technique designed for rigid severe kyphoscoliosis deformities.[2–4] VCR enables translation of spinal column and offers the advantage of a controlled manipulation of both the anterior and posterior column with active reconstruction. One-stage posterior reduction eggshell osteotomy can also be used to correct a sagittal and/or coronal congenital spinal curve imbalance.[5] Transpedicular eggshell osteotomy is a technique that should be considered for older patients who have congenital scoliosis with multiplanar spinal abnormalities.[5] Tokunaga *et al* reported a novel technique of staged vertebral decancellation technique;[6] and Bullmann *et al* described combined anterior and posterior instrumentation in

TABLE 1. Patient Demographics Showing Age, Pathology, and Distribution of Curve With Osteotomy Numbers and Extent of Fixation in Each Patient

Numbers	Age (yrs)	Sex	Follow-up (mo)	Type	Level (Apex)	Fixation (Extent)	PMVO n (Levels)
1	38	M	61	IS	T	T2–L3	3
2	11	F	58	CS	TL	T3–L4	3
3	22	M	56	CP	TL	T4–L5	3
4	26	F	47	IS	T	T2–L4	5
5	30	M	46	CS	TL	T6–L5	4
6	14	F	46	IS	T	T2–L4	5
7	11	F	41	IS	T	T3–L4	5
8	37	M	40	CP	T	T2–L3	5
9	26	M	40	CP	TL	T2–L5	4
10	32	M	38	CP	L	T4–L5	5
11	24	M	31	IS	TL	T4–P	4
12	18	M	28	IS	L	T8–S1	4
13	36	M	26	IS	TL	T1–L4	5

IS indicates idiopathic scoliosis; CP, cerebral palsy; CS, congenital scoliosis; T, thoracic; TL, thoracolumbar; L, lumbar; T4–P, T4 to pelvis; PMVO, posterior multilevel vertebral osteotomy.

severe and rigid idiopathic scoliosis.[7] Similarly, Wang *et al* introduced a single posterior approach for multilevel modified VCR in adults with severe rigid congenital kyphoscoliosis.[8] However, all such procedures have specific indications such as congenital kyphoscoliosis[9] or hemivertebrae or severe neuromuscular scoliosis, and therefore, it cannot be used in all kinds of deformity.

Suh *et al* have recently introduced and published their preliminary experience with posterior multilevel vertebral osteotomy (PMVO) in severe and rigid neuromuscular scoliosis.[10] The advantages of PMVO technique for correction of severe and rigid neuromuscular scoliosis through posterior only approach were that it does not deteriorate compromised lung functions and reduces the risk of neurologic injury as well as profuse intraoperative bleeding.[10] Additionally, this procedure can also be applied in other indications such as congenital scoliosis, idiopathic scoliosis, or even in revision surgeries with fused mass; however, there are no reports published till yet. Hence, in presence of severe kyphosis how does PMVO work, is to be investigated. In this article, we would like to investigate the application of PMVO as an extended indication in complex congenital, and severe idiopathic and nonidopathic kyphoscoliosis. The purpose of this article was to present little modification in the technique according to pathology and to report the clinical and radiologic results at minimum 2-year follow-up.

MATERIALS AND METHODS

In this prospective study, 13 patients with severe and rigid kyphoscoliosis (7 idiopathic, 4 cerebral palsy, 2 congenital) underwent surgery between 2004 and 2007 by a single spine surgeon (S.W.S.). There were 9 males and 4 females with an average age of 25 ± 9.5 years (range, 11–38 years). There were 5 thoracic, 6 thoracolumbar (TL), and 2 lumbar curves (Table 1). Average preoperative Cobb angle in coronal plane was 99.2° ± 29.6° (range, 60°–141°) with flexibility of 20.3% (average, 21.4°; range, 10°–36°) on bending radiograms. Pre- and postoperatively, thoracic kyphosis and lumbar lordosis was calculated by Cobb method; and pelvic obliquity was measured by Jacob line along horizontal plane on radiogram. We measured thoracic kyphosis and lumbar lordosis between maximally slopped endplates in the thoracic and lumbar spine. Average preoperative thoracic kyphosis was 73.6° ± 56.9° (range, –48°–159°). All patients had power Grade V in both lower limbs; however, their ambulatory status were different. Therefore, preoperative functional status was evaluated by Modified Rancho classification based on their ambulatory status.[11] All patients underwent single-staged posterior approach surgery with pedicle screw construct without any anterior approach. Additionally, they were all operated using multilevel posterior vertebral osteotomy (PMVO) technique at and near apex, developed by authors for the correction of severe and rigid curve with or without associated hyper kypholordosis from posterior-only approach.[10] According to pathology and associated hyperkyphosis or hyperlordosis, some modifications were applied to the original technique by Suh *et al*.[10] Intraoperative spinal cord monitoring was performed in all patients. Intraoperative spinal cord monitoring entailed measurement of motorevoked potentials elicited by multipulse transcranial electrical stimulation of motor cortex.[12,13]

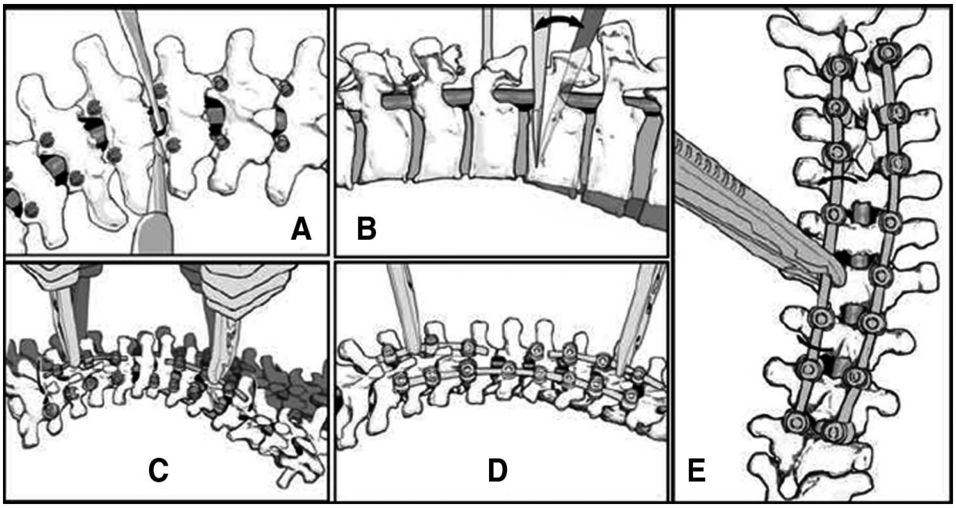

Figure 1. This figure shows illustration of posterior multilevel vertebral osteotomy technique (Reprinted with permission from Spine (Phila Pa 1976) 2009;34: 1315–2010). **A**, After completion of laminotomy at distal one-third of lamina cord is protected with dura protector, and osteotome was placed just above the pedicle and osteotomy carried out. **B**, Osteotomy was done till anterior one-third of the body and with proximal and distal movements of inserted osteotome, rest of the osteotomy accomplished. **C**, Short segment rod-screw construct was assembled, above and below the apex, on convex side to facilitate the cantilever manipulation. **D**, Holding the corrections with short segment construct on convex side, full rod-screw construct was assembled on concave side. **E**, Finally full rod-screw construct assembled on both side and further corrections achieved with rod-derotation maneuver. According to pathology and associated kyphosis, little modifications were applied while osteotomy and correction procedure.

Preoperative pulmonary function test was also performed for all patients.

Surgical Technique

All patients were operated in prone position with posterior-only approach. Before putting the skin incision, spinal cord monitoring was used to record the baseline potentials. Surgeon dissected spine subperiosteally up to the tips of transverse processes of vertebrae at all levels. Pedicle screws were inserted bilaterally using free hand technique at all before surgerydecided levels. Facetectomies were done at all levels bilaterally, including the apex, to facilitate maximum rotational correction. Thereafter, at and 1 or 2 levels proximal and distal to apex, partial laminotomies were performed involving distal 1/3 of laminae starting from convex to concave side with a little modification in the original technique. In patients with multilevel congenital scoliosis with multiple hemi or block vertebreae, laminotomy was performed through the normal laminae. For kyphoscoliosis that had fused ribs on concave or convex side, ribs were also cut in order to achieve mobility and facilitate the correction. After laminotomy, once the cord was visible bilaterally, it was protected with dural protector through laminotomy sites. With the help of 5 mm wide osteotome, osteotomies were performed through laminectomy sites on concave and convex sides, under direct vision, and protection of cord (Figure 1A). In case of multilevel congenital F1 hemivertebrae, hemivertebral excision was also performed at apex while in case of hyperkyphosis, posterior laminotomy was extended for 1/2 of the laminae posteriorly. The osteotomy levels were decided just above the pedicle which was supposed to be at a level below the upper endplate. Osteotome was inserted up to the anterior one-third of vertebral body to avoid any vascular or pulmonary injury (Figure 1B). Depth of osteotomy was decided on axial computed tomography scan before surgery for each level and side. Osteotomy for residual anterior one-third of the vertebral body was completed by shaking of osteotome in cephalad and caudal direction with osteotome being in situ until mobility of body was confirmed. After finishing multilevel vertebral osteotomy procedure, short segment rod-screw construct was assembled on convex side, proximal and distal to apical level leaving the apex free, for proceeding of cantilever maneuver (Figure 1C). With help of vice-grip applied on both proximal and distal rod-screw constructs, a repeated cantilever maneuver was performed gradually in order to obtain a release of contracted soft tissues and mobility. Here, cantilever movement was done in the opposite direction of the main deformity, such as in case of hyperkyphosis, the corrective force was lordosis and *vice versa*. Similar procedure was repeated at least 1 level above and belowthe apex at osteotomy level on convex side to get maximum correction. Finally, maintaining the correction force on convex side, precontoured rod was mounted over pedicle screws on concave side (Figure 1D). Finally, short segment rod-screw construct on convex side was replaced with full length construct. Subsequently, derotation maneuver with *in situ* bending of rod on hyperkyphosis or hyperlodosis level was performed to get additional correction (Figure 1E). After decortications of posterior laminae, posterior fusion was performed using local bone grafts mixed with cancellous allograft. Wound was closed in layers over 2-drainage tubes.

All patients underwent for radiogram and computed tomography scan after surgery, which were stored in our computerized Picture Archiving Computer System with preoperative data. A well-trained, experienced spine fellow (H.N.M.),

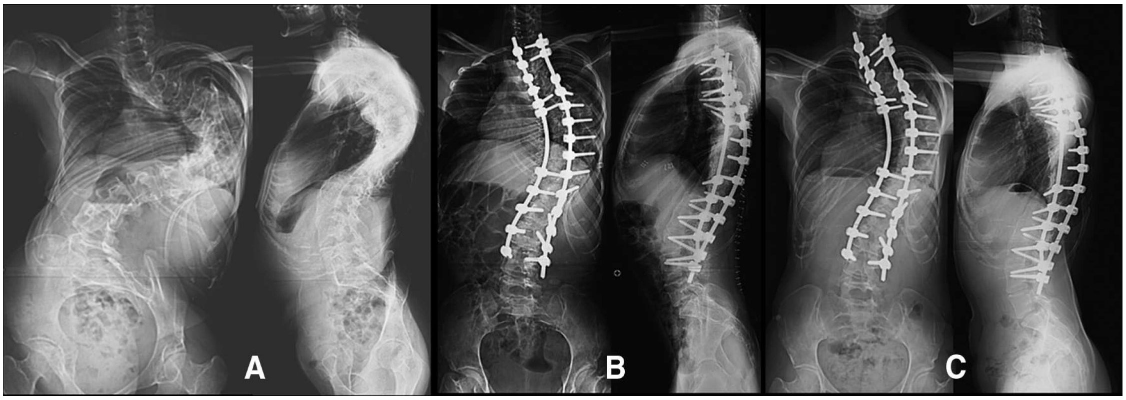

Figure 2. This figure shows (**A**) preoperative, (**B**) immediate postoperative, and (**C**) final follow-up radiogram showing coronal and sagittal curves in a 47-year female patient with idiopathic kyphoscoliosis, which was neglected. Five levels PMVO achieved good correction after surgery, which was maintained at final follow-up.

familiar with all the techniques, carried out all the calculations. The correction in Cobb angle, pelvic obliquity, thoracic kyphosis, and lumbar lordosis were compared with paired *t* test. For further evaluation, we divided our patients in 3 groups: idiopathic and nonidiopathic groups; and we evaluated our results between these groups using *t* test. $P < 0.05$ was considered significant for all the statistical calculations. All statistical analyses were performed using SPSS (SPSS, version 13, Chicago, IL) package.

RESULTS

Average preoperative Cobb angle, pelvic obliquity, thoracic kyphosis, and lumbar lordosis were 99.2° ± 29.6°, 8.6° ± 9°, 73.6° ± 56.9°, and −47.2° ± 63.2°, respectively, which improved after surgery to 44.7° ± 12.3°, 2.8° ± 2.9°, 45.3° ± 15.9°, and −47.7° ± 12.2°. All corrections were maintained at final follow-up (Table 1). There was 54.3% correction achieved in coronal plane; and, full correction was achieved in sagittal plane as thoracic kyphosis was restored within normal range in all patients (Figures 2, 3). Similarly, 66.4% correction was achieved in pelvic obliquity after surgery. Average number of osteotomy per patient was 4.2 ± 0.8 (range, 3–5) (Table 2).

Average blood loss and operative time was 3015 ± 1213 mL and 6.01 ± 1.09 hours, respectively (Table 3). Average hospital stay was 21.3 ± 6.6 days. All patients were discharged from hospital after suture removal. Once patients became hemodynamically stabilized, they were encouraged for physiotherapy and walking with the help of walker. There were 5, 4, 2, and 2 patients were in ambulatory functions class 1, 2, 3, and 4, respectively, at the time of operation (Table 4). At the time of final follow-up, all patients were able to walk; 10 independent (class 1) and 2 with the support of walker (class 2). There were 6 patients required intensive care unit (ICU) support after surgery during the hospital stay; 5 out of them required either ventilator or positive pressure ventilation support to improve the respiratory condition. Three patients had postoperative respiratory complications; of them, 2 had hemothorax and 1 had atelectasis. All pulmonary complications were due to associated thoracoplasty during which pleura was ruptured intraoperatively. Two more patients were hemodynamically unstable during postoperative phase and therefore were shifted to ICU. Average ICU stay was 4.1 ± 1.9 days. All patients did not have any respiratory consequences or pulmonary complications at the time of discharge; thus, all respiratory complications

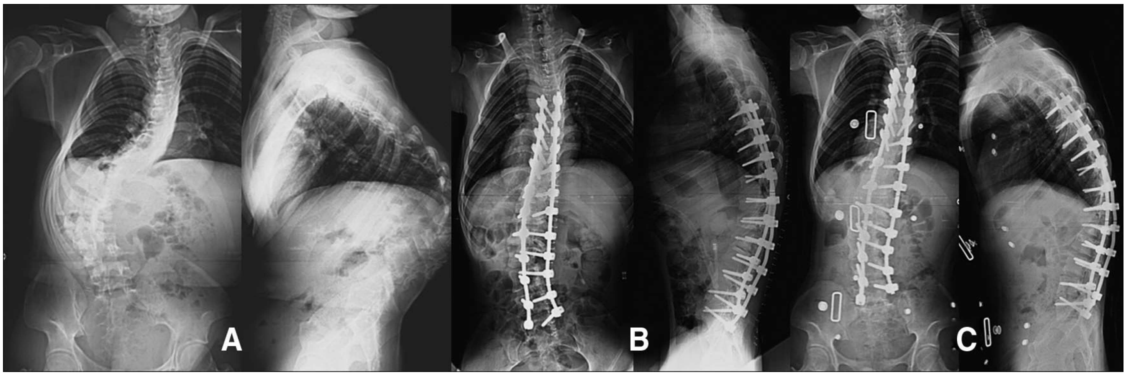

Figure 3. This figure shows (**A**) preoperative, (**B**) immediate postoperative, and (**C**) final follow-up radiogram showing coronal and sagittal curves in a 30-year male patient with neglected congential kyphoscoliosis. Four levels PMVO achieved good correction after surgery, which was maintained at final follow-up.

TABLE 2. Preoperative, Immediate Postoperative, and Final Follow-up Coronal and Sagittal Angles in Each Patient

	Preoperative				Immediate Postoperative				Final Follow-up			
Number	Cobb	Pelvis	Thoracic	Lumbar	Cobb	Pelvis	Thoracic	Lumbar	Cobb	Pelvis	Thoracic	Lumbar
1	112	7	95	−75	46	2	60	−55	48	3	65	−59
2	60	0	65	−69	34	0	48	−50	33	0	50	−49
3	60	7	88	−100	30	5	63	−75	33	5	65	−70
4	141	9	95	−81	66	1	45	−55	62	2	50	−50
5	75	5	101	−69	32	5	48	−41	31	1	49	−39
6	124	3	80	−70	51	0	31	−45	51	2	30	−40
7	60	0	85	−60	30	0	47	−50	28	0	45	−47
8	113	3	65	−55	45	0	55	−30	47	0	52	−32
9	124	12	130	−65	61	4	36	−33	59	3	42	−32
10	115	35	−48	108	53	9	36	−57	54	23	42	−57
11	68	12	75	−62	31	7	41	−33	35	8	43	−30
12	118	14	−33	75	48	3	9	−43	49	3	10	−38
13	120	5	159	−90	54	1	71	−54	52	1	72	−52

were transient. There were only 2 implant-related complications after surgery. Both were with idiopathic kyphoscoliosis. One of them had breakage of the distal screw, which did not cause any symptoms; and therefore was neglected. The other patient had screw prominence on the convex side of the curve (at thoracolumbar level), which caused pain due to screw head irritation. He was treated with revision procedure with removal of prominent screw and reestablishing the rod-screw construct. After revision procedure, his symptom was completely resolved. There was no neurologic injury intraoperatively on motorevoked potentials (MEP) or clinically after surgery. All patients were satisfied with the treatment at final follow-up using SF-36 Questionnaire, which was collected by registered nurse from the department.

TABLE 3. Table Shows Estimated Blood Loss (EBL), Operation Time, Hospital Stay, ICU Need and Stay, and Postoperative Complications in Each Patient

Number	EBL (mL)	Operation Time (h:min)	Hosp Stay (d)	ICU (d)	Ventilator (Yes/No)	Complication
1	1950	4:45	24		No	Distal screw breakage
2	1200	4:55	14		No	
3	2000	6:00	17		No	
4	3500	7:19	16	2	Yes	Screw prominence convex
5	1900	5:37	37		No	
6	4000	5:30	17	4	Yes	Atelectasis
7	2200	4:40	16		No	
8	2300	6:48	25		No	
9	2850	7:27	21		No	
10	5000	8:00	15	7	Yes	Hemothorax
11	3250	5:08	26	3	No	
12	4500	5:05	28	3	Yes	Hemothorax
13	4550	7:00	21	6	Yes	

ICU indicates intensive care unit.

TABLE 4. Ambulatory Status of Patients Before and After Surgery, Using a Modified Rancho Los Amigos Hospital Classification System

Functional Status	No. Patients (Preoperative)	No. Patients (Postoperative)
Class 1 (independently ambulating)	5	10
Class 2 (ambulatory with support/aids)	4	3
Class 3 (sitting without support)	2	0
Class 4 (sitting with support)	2	0
Class 5 (confined to bed)	0	0

DISCUSSION

Correction of severe and rigid scoliosis with associated kyphotic deformity is challenging due to high rate of associated neurologic complications.[14'15] Previously, Suh *et al* introduced their PMVO for the correction of severe and rigid neuromuscular scoliosis.[10] Our successful results in idiopathic/nonidopathic and congenital scoliosis associated with rigid kyphosis further established the reliability of PMVO as a technique. Additionally, no intraoperative or postoperative neurologie complications with this procedure suggested that it can be applied in any kind of kyphoscoliosis deformities to achieve desired correction.

Posterior-only procedures for the correction of scoliosis are being used by many surgeons nowadays, especially with pedicle screw instrumentation. Adyogan *et al* performed hemivertebrectomy and interbody fusion using posterior instrumentation with titanium mesh cage *via* the posterior approach in 19 patients (3 scoliosis, 5 kyphosis, and 11 kyphoscoliosis) with aged between 2 and 22 years.[16] Of these patients, 3 had scoliosis with 40.31° (range, 32°–58°), 5 had kyphosis with 53.41° (range, 28°–94°), and 11 had kyphoscoliosis (mean scoliosis 32.81° [range, 25°–53°]; kyphosis 49.41° [range, 30°–87°]); however, none had severe and rigid kyphoscoliosis. In several current studies, posterior resection of hemivertebra was performed and hook and rod systems are frequently used in closure of the defects.[17–20] Ruf and Harms used the pedicle screw rod system even in small children to ensure an effective closure and more correction of the defect.[21] Additionally, all patient in these series had simple hemivertebra; none had complex congenital kyphoscoliosis deformity. However, in our series of PMVO, we treated congenital complex kyphoscoliosis, which were severe and rigid with multilevel hemivertebrae and block vertebrae, using our innovative posterior multilevel osteotomies. Clinical and radiologic success in our patients has proved its applicability in congenital spinal deformities.

Correction of kyphotic deformity can be corrected using Smith-Peterson osteotomy (SPO)[22] or pedicle substraction osteotomy (PSO) procedures.[23] Bridwell *et al* concluded that PSO is a useful procedure for patients with fixed sagittal imbalance. A worse clinical result is associated with increasing patient comorbidities, neurologic risks, pseudarthrosis in the thoracic spine, and subsequent breakdown caudad to the fusion.[23–25] Additionally, if the patient is having hyperlordosis, it is not possible to correct it with SPO or PSO. However, with PMVO as shown in our technique, it is possible to achieve correction in hyperlordosis stage by creating flexibility at multiple levels and correcting in opposite direction. Moreover, creating multiple levels flexibility would be helpful in correcting the deformity in both coronal and sagittal plane. Kim *et al* reported satisfactory clinical and radiographic outcomes for 35 patients with a minimum 5-year follow-up despite needing pseudarthrosis revision. They included patients with multiple diagnosis including idiopathic and degenerative scoliosis, posttraumatic and Scheuermann kyphosis with an average thoracic kyphosis 22° ± 16.2° and lumbar lordosis −16° ± 20.8°, which were not very severe. However, in our series along with coronal plane deformity, we had preoperative thoracic kyphosis 73.6° ± 56.9° and lumbar lordosis −47.2° ± 63.2°, which were corrected to 45.3° ± 15.9° and −47.7° ± 12.2°, respectively. We additionally achieved 54.3% correction in coronal plane from preoperative 99.2° ± 29.6° to postoperative 44.7° ± 12.3°. Suk *et al* achieved correction in thoracic kyphosis from preoperative 30.7° ± 40.0° to 33.3° ± 9.1° after surgery; and in lumbar lordosis preoperative −22.1° ± 48.3° to −45.1° ± 12.5° after surgery along with 61% correction in coronal plane using posterior vertebral column resection (PVCR).[3] However, the average blood loss in their study was 7034 mL, which was higher than ours. Additionally, in our study, the correction in thoracic kyphosis was better than their study. In fact, in their study, average thoracic kyphosis was normal at the time of operation while it was hyperkyphotic in our study, which was brought to the normal range using PMVO. Thus, our results proved that PMVO is a safe technique in correcting kyphoscoliosis deformity. They additionally encountered 1 complete paralysis out of 16 patients using PVCR. We did not face any partial or complete neurologic injury in our series of 13 patients with severe and rigid kyphoscoliosis. The reason behind avoiding neurologic injury in our study is that in PMVO, osteotomy were done at multiple levels, and therefore the amount of correction was distributed at 3 to 5 levels. On the other hand, in PVCR correction is mainly done at the single osteotomy level. Therefore, there exists a theoretically higher chance of cord injury. Additionally, all surgeries were done under cover of MEP neuromonitoring. All patients achieved the preoperative mobility with improved cosmetic and functional status after surgery.

By creating vertebral osteotomy, Thomasen maintained the height of the anterior column with hinges on the anterior longitudinal ligament; in contrast to PVCR or PSO, which compress the cord by spinal column shortening.[26] Using the same principle of Thomasen of transpedicular wedge resection osteotomy and anterior longitudinal ligament as a hinge, Berven *et al* achieved almost 60% correction in sagittal balance in their 13 patient series.[27] They concluded that transpedicular wedge resection osteotomy is an effective procedure for the management of fixed sagittal deformity and is generalizable for multiple etiologies. Simultaneous correction of coronal deformity is possible. The clinical value of the procedure is demonstrated in high rates of patient satisfaction. Boachie-Adjei *et al* also showed satisfactory clinical results with transpedicular lumbar wedge osteotomy for fixed sagittal deformity in 17 patients.[28] The principle in PMVO in our series was the same, maintaining the hinge at anterior longitudinal ligaments at multiple levels and thereby, increasing flexibility by repeated hinge movements. The main difference in our technique was the level of osteotomy at above the pedicle not at the pedicle. Thus, we could preserve the pedicle at all levels for the pedicle screw fixation to apply the correction force. We proved that PMVO can be used safely in all kinds of spinal deformities without increasing risk to the neurologic structures. Literature also described good results for rigid coronal and sagittal plane deformity using combined anterior and posterior approach[7,29,30] or staged posterior approach,[31] which ultimately increase the hospital stay and thereby expenses as well. However, PMVO is a simple and single-staged posterior-only operation that can be easily applied in any kind of deformity and modified according to the need.

Although there are, of course, few issues to consider using PMVO. First one is that the number of patients was less compared to other studies in the literature. Therefore, a larger prospective study with a longer follow-up would be recommended to establish it as one of the standard posterior-only technique. Additionally, the surgeon is required to acquire enough experience in inserting the pedicle screws in complex deformities. Multilevel osteotomy procedure sometimes can result into profuse intraoperative bleeding, which should be handled with due care to avoid neurologic complications although we did not encounter any experience. And hence, possible neurologic injury cannot be ignored while using this technique.

In conclusion, using PMVO we achieved satisfactory clinical and radiologic results in patients with severe and rigid scoliosis with associated hyperkyphosis at minimum 2-year follow-up. It was safely applied with some modifications in the original technique for complex congenital scoliosis with multilevel hemi or block vertebrae and idiopathic/nonidiopathic spinal deformities.

➢ Key Points

- ❑ Thirteen patients (7 idiopathic, 4 cerebral palsy, 2 congenital scoliosis) with severe and rigid kyphoscoliosis were operated by posterior-only correction with pedicle screw fixation using PMVO.
- ❑ As per pathology, and associated severity of kyphosis little modification in the original technique was applied while correction and osteotomy procedure. A 54.3% correction was achieved in coronal plane, and full correction was achieved in sagital plane as thoracic kyphosis was restored within normal range.
- ❑ There was no neurologic injury intraoperatively on MEP or clinically after surgery.
- ❑ It can be safely applied with modifications in original technique for complex congenital scoliosis with multilevel hemi or block vertebrae and idiopathic/nonidiopathic spinal deformities.

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