ORIGINAL ARTICLE

Role of Pedicle Subtraction Osteotomy in the treatment of Kyphotic Deformity of the Spine.

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Each author of this article fulfilled ALL 4 Criteria of Authorship:

1. Conception and design or acquisition of data, or analysis & interpretation of data.
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ABSTRACT

Objective: To determine the functional and radiological outcome of Pedicle Subtraction Osteotomy (PSO) in the treatment of kyphotic deformity of the spine.

Methods: This descriptive study was conducted in Orthopaedic unit Karnali Academy of Health Sciences, Jumla Nepal and Orthopaedic and Spine unit Lahore General Hospital from 23rd March 2017 to 23rd March 2020.All patients with kyphotic deformity and sagittal imbalance fulfilling the inclusion criteria were treated with PSO. Post operative functional and neurological outcome was assessed with Oswestry Disability Index(ODI) Questionnaire and Frankel Grade system while radiological outcome was evaluated by measuring the Kyphotic angle. Patients were graded as per ODI results as having minimal disability (0 to 20% score), moderate (21% to 40%), severe (41% to 60%), crippled (61% to 80%) and bed bound (81% to 100%) disability. Neurological categorization of the patients were done as per Frankel Grade system from A(Complete motor and sensory deficit) to E (Complete motor and sensory recovery).Comparison of pre operative and post operative ODI and Frankel Grade system was done and *P* value was calculated with paired Sample-t test and Chi-square test and. *P* value <0.05 was considered significant.

Results: We operated 15 patients with PSO. The mean age of our patients was 21.6±8.5 years. Female patients were 9(60%) and males were 6(40%). The mean pre-operative ODI of 44.6% (Sever disability) was statistically improved ($P<0.05$) to 18.66% (Minimal disability) post operatively at one year follow up. The mean pre-operative and post-operative kyphotic angles were 34.72°±4.34° and 1.88°±21.13° ($P<0.05$) respectively. Neurological deficit improved from Frankel Grade D to E in 1(6.66%) patient while 1(6.66%) patient had post-operative neurological deficit with Frankel grade C at one year follow up.

Conclusion: Pedicle subtraction osteotomy is a safe and valid surgical technique for the correction of kyphotic deformity of the spine as shown by excellent functional and radiological outcome achieved in majority of our patients.

Keywords: Cobb angle, Kyphosis, Pedicle Subtraction Osteotomy, Sagittal Imbalance

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INTRODUCTION

Kyphosis refers to the apical-dorsal sagittal contour of the thoracic and sacral spine.[1] Normal physiological kyphosis is 20° to 40° Cobb angle as measured from T2 to T12.[2] As a pathological entity kyphosis is either an abnormal excessive kyphotic curvature of the spine in the thoracic and sacral spine or loss of lordosis in cervical and lumbar regions.[3] Kyphosis can have various etiologies ranging from post-traumatic, post-tuberculosis to Scheuermann's

disease, ankylosing spondylitis and neurofibromatosis.[4] Indications for surgery in patients with kyphosis include pain, progression of the deformity, neurological deficit, cardiopulmonary compromise, and cosmetic concerns.[5] Many surgical techniques are used to treat kyphotic deformity of the spine. These include Pedicle Subtraction Osteotomy (PSO), Smith-Peterson Osteotomy (SPO) and Posterior Vertebral Column Resection (PVC).[6,7] Each surgical technique has its own merits and demerits. PSO can correct the deformity to a greater extent than SPO but is technically difficult and is associated with prolonged surgical time, more blood loss and morbidity.[8] PVCR can correct the deformity to much a greater degree than PSO both in coronal and sagittal planes but has greater frequency of neurological deficit.[9]

Pedicle Subtraction osteotomy (PSO) was first introduced by Thomasen in 1985.[9] In this technique through a single posterior approach following resection of the pedicles, posterior ligaments and facets, a wedge of the vertebral body is decancellate using a trans-pedicular passageway followed by wedge-shaped closure and correction of the kyphosis through posterior shortening. The anterior vertebral body column serves as a hinge for this closing wedge osteotomy and moves freely. The sagittal translation or movement of the vertebral column however, may take place at the osteotomy site if the hinge shifts during surgery.[9-12]

The objective of our study was to determine the functional and radiological outcome of Pedicle Subtraction Osteotomy (PSO) in the treatment of kyphotic deformity of the spine.

MEHTODS

We conducted this descriptive study in Orthopaedic unit Karnali Academy of Health Sciences, Jumla Nepal and Orthopaedic and Spine unit Lahore General Hospital from 23rd March 2017 to 23rd March 2020.All patients of both gender and all ages with thoracolumbar kyphotic deformity, sagittal imbalance of >10 degrees, circumferential involvement of multiple segments and stiff spine were included. Patients with normal coronal and sagittal alignments, previously surgically treated patients and those with revision surgery were excluded. The study was approved by the Ethical Committee of both hospitals hospital. Informed written consent was obtained from all study participants. Complete history, physical examination and relevant investigations were carried out in all patients.

Surgical Technique

The primary surgeons were Thakur AK and Hanif M. Standard surgical technique of PSO as described by Gupta[13]was adopted for all cases. The patient was placed prone on a radiolucent table that allowed extension for helping in the correction of osteotomy. The image intensifier was stand-bye for usage during surgery. The correct level was identified with radiographs and image intensifier. The posterior spinal elements were exposed with subperiosteal dissection. We used neuromointor for assessing per operative neurology and adjustments accordingly. Pedicle screws were placed above and below the osteotomy site. One level proximal to osteotomy site and at the level of osteotomy decompression of the posterior elements were done. The vertebral body was decancellate with the help of curettes and high speed burr. After placement of temporary rods the posterior vertebral wall was impacted into the vertebral body followed by loosening of the temporary rods. The osteotomy was closed by extending the table or manually pushing the spine and correcting the lordosis. The rods were tightened. The final stabilization was achieved with help of main rod and connecting multiple segments above and below the osteotomy site. For decompression of the spine total posterior laminectomies at PSO level and above were performed. We used minimum two pairs of pedicle screws above and below the level of PSO. The pedicle screws were inserted with free hand technique. Local bone grafting was performed to facilitate healing of the osteotomy.

Post operatively thoracolumbar orthosis was advised day time for 4 months. Supervised physiotherapy was advised for ambulation and isometric abdominal and back exercises. Follow up visits were scheduled monthly for one year. Final assessment at one year included functional and neurological outcome with Oswestry Disability Index (ODI) Questionnaire[14] and Frankel Grade system[15] while radiological outcome was evaluated by measuring the Kyphotic angle. (Fig. I). The ODI questionnaire has 10 sections namely pain intensity, personal care like dressing, washing, lifting, walking, sitting, standing, sleeping, sex life, social life and travelling. Each section has 5 marks(0 to 5) with 50 possible total score. The score is calculated as percentage of total. Result of ODI is interpreted as minimal disability (0 to 20% score), moderate (21% to 40%), severe (41% to 60%), crippled (61% to 80%) and bed bound (81% to 100%) disability. Frankel Grading system was interpreted as Frankel grade A (complete sensory and motor deficient), B

(sensory deficits below the level of injury), C (some degree of sensory/motor functions exist but recovery of motor function is useless), D (useful but abnormal motor function) and E (complete sensory/motor recovery).

We analysed our data with SPSS version 27.Frequency and percentage was calculated for qualitative variables while mean and standard deviation was calculated for quantitative variables. The pre operative and post operative ODI and Frankel Grade system was compared and *P* value was calculated with paired Sample-t test and Chi-square test and. *P* value <0.05 was considered significant. The data was presented in table where necessary.

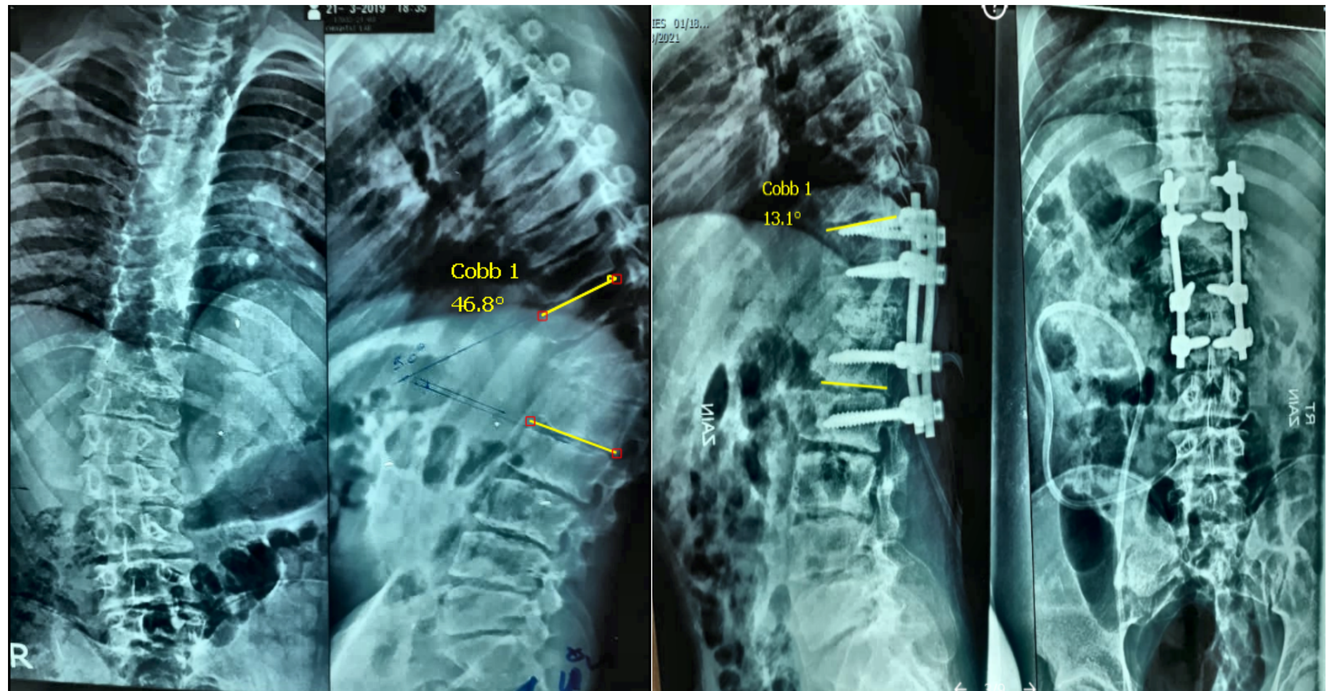

Fig. I: Radiographs showing pre operative Cobb angle 46.8° reduced to 13.1° after PSO.

RESULTS

In this study 15 patients of kyphosis were treated with PSO. The mean age of our patients was 21.6±8.5 years. Female patients were 9(60%) and males were 6(40%). The aetiology of kyphosis was trauma in 7(46.66%) patients, tuberculosis in 3(20%), ankylosing spondylitis in 2 (13.33%), mucopolysaccharidosis in 1 (6.66%), Scheuermann's kyphosis in 1 (6.66%) and Spondyloptois in 1(6.66%) patient. The mean pre-operative ODI of 44.6 % (Sever disability) was statistically improved (^{P} value 0.0029) to 18.66 % (Minimal disability) post operatively at one year follow up. (Table I) Majority (93.33%, n=14) of our patients had Frankel E while only 1 (6.6%) patient had Frankel D prior to surgery. The neurological state was Frankel E in 14 patients (93.3%) and Frankel C in 1 patient (6.6 percent) over the follow-up period.(*P* value 0.03) One patient with neurological deficit improved from Frankel grade D to E and one patient had post-operative neurological deficit with Frankel grade C at one year follow up. The mean pre-operative and post-operative kyphotic angles were 34.72°±4.34° and 1.88°±21.13° (*P* value 0.001) respectively.(Table II) The maximum correction achieved was 39.6^{0}±3.1 with a mean of 30.2^{0}±5.3. Per operative dural tear was noted in 1(6.66%) patient but repaired successfully. Post-operative complications occurred in 2(13.33%) patients including neurological deficit in one and malpositioned screw causing transient neurological deficit in another but improved after revision of the screw. There was anterio-posterior translation (List) at the osteotomy site in 03(20%) patients post operatively without any neurological deficit.

Table I: The pre operative and post operative Oswestry Disability Index (ODI) Score of our patients.

S. No	Aetiology of kyphosis	Age (Yrs)/ Gender	Oswestry Disability Index (ODI) Score.	
			Pre-op %	Post-op %
1	Post-Tubercular Kyphosis	18/F	15/50 x 100 = 30	10/50x100 = 20
2	Post-Tubercular Kyphosis	14/M	10/50 x 100 = 20	7/50 x 100 =14
3	Scheuermann's kyphosis	15/F	12/50 x 100 = 24	8/50 x 100 = 16
4	Ankylosing spondylitis	28/M	15/50 x 100 = 30	13/50x100 =26
5	Ankylosing spondylitis	18/F	10/50 x 100 = 20	5/50x100 = 10
6	Mucopolysacchridosis	24/F	39/50x 100 = 78	18/50x100 = 36
7	Post Traumatic Kyphosis	45/F	19/50x 100 = 38	38/50x100 = 76
8	Post Traumatic Kyphosis	14/M	32/50x100 = 64	0/50x100 = 0
9	Post Traumatic Kyphosis	15/M	32/50x100 = 64	1/50x100 = 2
10	Post tubercular kyphosis	14/M	19/50x 100 = 38	0/50x100 = 0
11	Post Traumatic Kyphosis	28/M	16/50x 100 = 32	10/50x100 = 20
12	Post Traumatic Kyphosis	16/F	22/50x100 = 44	3/50x100 = 6
13	Spondyloptois	24/F	31/50x100 = 61	18/50x100 = 36
14	Post Traumatic kyphosis	22/F	33/50x100 = 66	2/50x100 =4
15	Post Traumatic Kyphosis	30/F	30/50x100 = 60	7/50x100 = 14

Table 2: Demographic and clinical details of our study participants.

S. No	Disease	Age (Yrs)/ Gender	Level	Kyphotic angles (degree)		Total correction Post-Op List (mm)		Frankel Grade		ICU Stay	Blood loss (Liter)	Surgery Time (Hour)
				Pre-OP	Post-op			Pre-op	Post-op			
1	Post-tubercular kyphosis	18/F	T10	70.1	35.3	34.8	0	D	E	1	1.9	6
2	Post-tubercular kyphosis	14/M	L2	68.5	38.2	30.3	0	E	E	2	2.2	5
3	Scheuermann's kyphosis	15/F	L2	60.8	24.5	36.3	0	E	E	1	3	4.5
4	Ankylosing spondylitis	28/M	L2	20.4	-7.1	27.5	0	E	E	2	1.6	5
5	Ankylosing spondylitis	18/F	L2	24.2	-15.2	39.4	5	E	E	1	2	5
6	Mucopolysacchridosis	24/F	L2	12.3	-27.3	39.6	4	E	E	1	1.8	4
7	Post Traumatic Kyphosis	45/F	L3	45	15.7	29.3	0	E	C	1	1.5	4.5
8	Post Traumatic Kyphosis	14/M	L1	42	6.9	35.1	0	E	E	0	1.6	4.5
9	Post Traumatic Kyphosis	15/M	L2	28.4	-8.1	36.5	0	E	E	0	1.5	4
10	Post tubercular kyphosis	14/M	T12	46.8	13.1	33.7	0	E	E	1	2	5
11	Post Traumatic Kyphosis	28/M	L1	34.2	9.1	25.1	0	E	E	0	1.8	4
12	Post Traumatic Kyphosis	16/F	L3	15.7	-12.7	28.4	3	E	E	0	1.5	4
13	Spondyloptois	24/F	L4	1.5	-32.3	33.8	0	E	E	0	2	5
14	Post Traumatic kyphosis	22/F	L2	15.4	-9.4	24.8	0	E	E	0	2	5
15	Post Traumatic Kyphosis	30/F	L1	35.6	-2.5	33.1	0	E	E	O	1.8	5

DISCUSSION

Pedicle Substraction Osteotomy (PSO) is a an effective and safe surgical technique for the correction of kyphotic deformity of the spine. The ideal patient for PSO however, is one with greater sagittal imbalance and requiring at least 30° correction.[16] In our study 15 patients of kyphotic deformity were treated with PSO. The post operative functional outcome showed a significant improvement as indicated by improvement in the

mean pre-operative ODI score of 44.6 %(Sever disability) to 18.66% (Minimal disability) post operatively at one year follow up. (*P*<0.05) Neurological deficit improved from Frankel Grade D to E in 1 (6.66%) patient in our seriers. The mean pre-operative and post-operative kyphotic angles were 34.72°±4.34° and 1.88°±21.13° (*P*<0.05) respectively. Hyun and colleagues[17] treated 13 patients of fixed sagittal deformity with PSO. At 73 months post operative follow up they noted a statistically significant improvement (*P*<0.001) improvement ODI from pre operative 55.4±13.6 to 30.2±16.5 post operative. In our study majority (46.66%, n=7) of kyphosis were traumatic. Heary[18] treated three patients of post traumatic kyphotic deformity with PSO and documented a solid arthrodesis with pain relief and sagittal improvement of 51˚. Lin G *et al*[19] retrospectively reviewed the data of 11 patients of sever thoracolumbar kyphosis who were treated with POS and pedicle screw instrumentation. Post operative results revealed that global kyphosis had improved from 74.1° to 40° with 48.8% correction achieved. Thoracic kyphosis, thoracolumbar kyphosis ,and lumbar lordosis significantly improved. (P<0.05). Similarly significant improvement (P<0.05) in post operative functional outcome was noted as assessed with Scoliosis Research society-22 Questionnaire (SRS-22)

The design of our study was descriptive. El-Sharkawi and Koptan[20] compared PSO with Anterior Corpectomy and Plating (ACP). They performed PSO in 43 thoracolumbar kyphosis due to trauma and 37 with ACP. Their follow up period was two years. The PSO group had kyphotic correction of 29.8˚ while ACP had correction of 22˚ (*P*=0.001).The VAS and ODI were significantly better in PSO than in ACP. Similarly the ACP had more frequent and more serious complications than PSO. These authors concluded that PSO is a safe and more effective technique than ACP for correcting post traumatic kyphotic deformity of the spine.

In our study the maximum correction achieved was 39.6^0±3.1 with a mean of 30.2^0±5.3. Our results are comparable with other studies reported in literature. Berven[21] achieved correction of 30^0, Bridwell *et al*[22] 33^0 and Ahn *et al*[23] 24^0.

Our study had few complications. We noted per operative dural tear in 1(6.66%) patient but repaired successfully. Post-operative complications occurred in 2(13.33%) patients including neurological deficit in one and malpositioned screw in other. Daubs[24] reviewed the record of 65 patients of PSO and documented major complications in 10(15.4%) patients and minor complications in 15(23%) patient. Neurological deficit was the most common major complication noted in 4(6.2%) patients including permanent foot drop and paraplegia. Daubs was of the opinion that the complication rate was not associated with surgeon's experience. Contrary to Daubs conclusion Choi[25] documented that the complication rate of PSO was acceptable only if surgeon was experienced and had performed minimal of 20 cases of PSO. To reduce the major complication rates of PSO Ames advocated to performed PSO surgery with the help of two spine surgeons rather than one surgeon.

Our study had few limitations. The design of our study was descriptive. Our sample size was small. Our follow up was short. We were unable to utilize pre operative software programs to simulate curve correction with PSO. We therefore recommend further studies to address these limitations and verify the effectiveness of PSO in the treatment of kyphotic deformity of the spine.

CONCLUSION

Pedicle subtraction osteotomy is a safe and valid surgical technique for the correction of kyphotic deformity of the spine as shown by excellent functional and radiological outcome achieved in majority of our patients.

Conflict of Interest: None

Grants/Funding: None

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