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Modified Pedicle Subtraction Osteotomy for Posttraumatic Kyphosis: Long Term Follow-Up

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Abstract

Background Data: Post traumatic kyphosis (PTK) of the thoracolumbar spine is a severe complication of spine fractures and its management can be quite challenging. Pedicle subtraction osteotomy includes posteriorly based wedge resection of the posterior column and both pedicles, with the hinge located at the anterior cortex of the vertebral body. It has been developed to achieve significant deformity correction. It does not involve the adjacent disc which is usually affected and represents a cause of pain, neurological compression and progression of deformity. Modified pedicle subtraction osteotomy (MPSO) including resection of posteriorly based wedge of posterior column and both pedicles together with the damaged disc to achieve correction and solid fusion between the affected vertebra and the adjacent one. It seems to be more suitable for the management of PTK.

Purpose: The purpose of this prospective study is to review our experience with modified Pedicle subtraction osteotomy (MPSO) technique for the management of thoracolumbar posttraumatic kyphosis (PTK).

Study Design: Prospective cohort clinical case study.

Patients and Methods: From February 2010 to July 2014, 14 consecutive patients with PTK were managed by MPSO. The patients were followed clinically and radiologically. Back pain VAS, Denis work scale and regional kyphotic angle (RKA) were recorded and analyzed preoperatively, postoperative and at the latest follow up.

Results: The study included 14 patients with an average age of 38.43±6.63 (26 - 48) years. The follow up period was 46.29±15.45 months. The average operative time was 286.43±12.74 minutes and per-operative blood loss

was 1017.86±198.75 ml. Back pain VAS improved from 8.21±0.77 preoperatively to 2.50±0.73 at the last follow-up (P=0.034), and the Denis work scale improved from 4.43±0.49 preoperatively to 1.64±1.23 at the last follow-up (P=0.022). Neurological improvement occurred in one patient from ASIA grade D to E with no postoperative deterioration in any case. The regional kyphotic angle (RKA) significantly improved from 42.07±5.28° preoperatively to 2.67±2.58° after surgery (P=0.04) with a mean correction of 38.47±5.42°. The loss of correction was 1.92±0.73° at the latest follow-up. The complications included 2 dural tears and 3 postoperative wound infections.

Conclusion: MPSO technique provides significant correction of patient's kyphosis with a risk profile similar to a standard PSO procedure. (2016ESJ122)

Keywords: Osteotomy, posttraumatic, kyphosis

Introduction

Posttraumatic kyphosis (PTK) represents a potential serious complication of unstable injuries of the thoracolumbar spine which often occurs because of neglected or inadequately treated fracture.[10,18] Patients with focal kyphotic deformity equal to or greater than 30° have an increased risk of chronic pain or neurologic deficit.[19] Pain intractable to conservative treatment, progressive deformity, or progressive neurological deficit are the main indications for surgical intervention.[5,7,18] However, the treatment of such patients can be quite challenging.[6,13]

Pedicle subtraction osteotomy (PSO) was first described by Thomasen to achieve significant deformity correction in a single stage, posterior-approach procedure with the advantage of obtaining correction through both the anterior and posterior spinal column, thereby maximizing the healing potential while avoiding stretch on the major vessels and viscera anterior to the spine.[17]

PSO is performed by removing the posterior elements and both pedicles, decancellating the vertebral body, and closure of the osteotomy by hinging on the anterior cortex. An average of 30° to 40° correction can be achieved with a one level PSO.[12,13,17] However, in most cases of PTK, the adjacent intervertebral disc usually represents a component of the deformity visible at the time of trauma or later on because of degenerative changes and it is also a potential source of pain and neural compression, hence the modification of the standard technique of PSO by including the damaged disc in the resection to achieve correction and solid fusion seems to be more suitable for PTK especially in severe cases.[14]

The purpose of this prospective study is to review our experience with a modification of the well-described pedicle subtraction osteotomy for the correction of thoracolumbar PTK, showing the surgical technique and long term follow-up.

Patients and Methods

Fourteen consecutive patients (10 males and 4 females) were surgically treated for symptomatic thoracolumbar PTK with MPSO during the period from February 2010 to July 2014. All the patients signed a preoperative written consent and the study was approved by the institutional review board.

The main complaint was Chronic back pain not responding to conservative treatment for at least 6 months and neurological deficit in 3 patients. Although not an indication for surgery 6 patients were extremely displeased by their clinical appearance. The exclusion criteria were;

previous thoracolumbar spine surgery, spine malignancy or infection.

The operative time, intraoperative blood loss and operative complications were recorded. The neurologic status was assessed according to the American Spinal Injury Association (ASIA) Impairment Scale.[11] The clinical assessment was done using the back pain visual analogue scale (VAS) (0 as no pain to 10 as maximal pain) [20] and Denis Work Scale.[4]

Radiologically, all the patients were evaluated using standing lumbosacral (AP) and lateral radiographs at three time-points: preoperatively, postoperatively, and at the latest follow-up. Regional kyphotic angle (RKA) was measured as the angle between superior endplate of vertebral body above the affected level and inferior endplate of vertebral body below the affected level.[8] (Figure 1) Measurements were done and repeated twice by 2 blinded radiologists and the averages were taken. Assessment of radiological fusion at follow-up was based on the presence of trabecular bone bridging at the osteotomy site according to Brantigan et al,[1] CT scanning was used for preoperative deformity assessment and also to evaluate bone fusion at the latest follow-up (Figure 2). Preoperative MRI was used only to evaluate nerve compression in cases with neurological deficit.

Operative Technique:

Under general anesthesia the patient was placed in a prone position on a radiolucent table with both hips and knees extended and all bony prominences well padded. Through a standard midline approach, subperiosteal exposure was performed from two levels above to two levels below the apex of the deformity from the spinous processes to the tips of the transverse processes bilateral.

Care was taken to avoid disruption of the interspinous ligaments and facet joint capsules at levels not included in the fusion. Under fluoroscopic control, 2 pairs of pedicle screws were inserted proximal and distal to the osteotomy site. Reduction screws were used in the distal vertebrae.

The entire neural arch at the resection level was removed together with the proximal and distal laminae to avoid dural sac impingement during osteotomy closure. The costotransverse joints and rib heads were also removed for thoracic osteotomy. Resection of the pedicle was done using an osteotome after protecting the dural sac. Complete discectomy of the chosen abject disc and partial corpectomy using rongeurs and curettes through the base of the resected pedicle was then performed.

At this stage, a contoured rod was fixed to one side to maintain the stability of the spine followed by resection of the remaining parts of the vertebral body and disc from the opposite side in the same manner. The adequacy of osteotomy was then fluoroscopically checked, followed by curettage of the inferior end plate of the proximal vertebra. Bleeding was controlled by bipolar electrocautery and gelfoam. Insertion of the second contoured rod followed with loosening of screws bilaterally. Closure of the osteotomy was performed by gradual extension of the operating table followed by compression of the screws with keeping an eye on the dural sac to avoid any compression. The rods were then finally tightened to the screws.

Bone chips harvested from the osteotomy site were packed in the osteotomy site and posterolateral gutter for fusion, followed by a standard wound closure. Drains were removed when blood collection was < 50 ml per 24 h. Patients were typically allowed to ambulate within 24 – 48 hours according to pain tolerance using a brace for 3 months.

Statistics:

Data were statistically analyzed using SPSS software (SPSS, Chicago, IL). Significant differences were investigated using T-test. Values are presented as mean ±SD. The level of significance was set at a P value of < 0.05.

Results

The average operative time was 286.43±12.74 minutes, and the average intraoperative blood loss was 1017.9±198.8 ml. All the patients received intraoperative blood transfusion with no complications. In 5 patients with blood loss >1000 ml, 2 unites were given while only one unite was given for the other 9 patients. The average delay between spine fracture and the deformity correction was 11±2.17 (7 – 15) months. The follow up period was 46.29±15.45 (24–74) months.

Clinical Outcomes:

Back pain VAS improved from 8.21±0.77 preoperatively to 2.50±0.73 at the last follow-up (P=0.034), and the Denis work scale improved from 4.43±0.49 preoperatively to 1.64±1.23 at the last follow-up (P=0.022). Postoperative neurologic improvement occurred in one patient from ASIA grade D to E with no postoperative deterioration in any case.

Radiological Outcomes:

The RKA significantly improved from 42.07±5.28° preoperatively to 2.67±2.58° after surgery (P=0.040) with a mean correction of 38.47±5.42°. The loss of correction was 1.92±0.73° at the latest follow-up, with all the patients showing evidence of solid fusion.

Complications:

There were two dural tears which were repaired primarily with no late sequelae. Three superficial postoperative wound infections occurred and responded to antibiotic treatment alone. There was no intraoperative segmental vessel, nerve root, or pleural injury.

Table 1. Patient Characteristics, Operative, Clinical and Radiological Data.

No	Age(y) /Sex	Affected level	PreOp ASIA score	PostOp ASIA score	Delay (month)	Op time (min)	Blood loss (ml)	PreOp Back pain VAS	Last Back pain VAS	PreOp Denis work scale	Last Denis work scale	PreOp RKA°	PostOp RKA°	Last RKA°	Follow up (month)
1	32/M	T 9	A	A	11	310	1300	7	2	5	5	52	11.3	13	74
2	45/M	L1	D	D	9	290	1050	9	3	5	4	32.7	1.7	3.3	70
3	44/F	L1	E	E	10	300	850	9	4	4	1	45	1.3	3.3	64
4	30/F	L1	D	E	7	290	900	8	3	4	1	35.3	1.7	3	59
5	39/M	L1	E	E	13	280	900	8	2	4	1	40.7	1.7	3.3	55
6	32/M	T12	E	E	10	300	1500	9	3	5	2	43.3	3.7	5.3	49
7	47/M	L1	E	E	9	280	1000	8	2	5	1	36.7	1.7	3.7	44
8	26/M	L1	E	E	12	285	950	7	3	4	1	47.7	1.3	2.7	41
9	37/F	T12	E	E	15	305	1250	9	3	4	1	45	4.7	6.3	39
10	45/M	L1	E	E	13	270	1050	9	2	5	2	38	2	3.7	37
11	40/M	L1	E	E	10	280	950	8	2	5	1	47.3	2	4.3	36
12	48/M	L1	E	E	9	270	800	8	2	4	1	42.7	2	3.7	30
13	39/F	L1	E	E	12	280	750	9	3	4	1	45.3	1.3	3.3	26
14	34/M	L1	E	E	14	270	1000	7	1	4	1	37.3	1	2.7	24
Mean±SD	38.4±6.6				11±2.17	286.4±12.7	1017.8±198.7	8.2±0.8	2.5±0.7	4.4±0.5	1.6±1.2	42.1±5.3	2.7±2.6	4.4±2.8	46.3±15.6

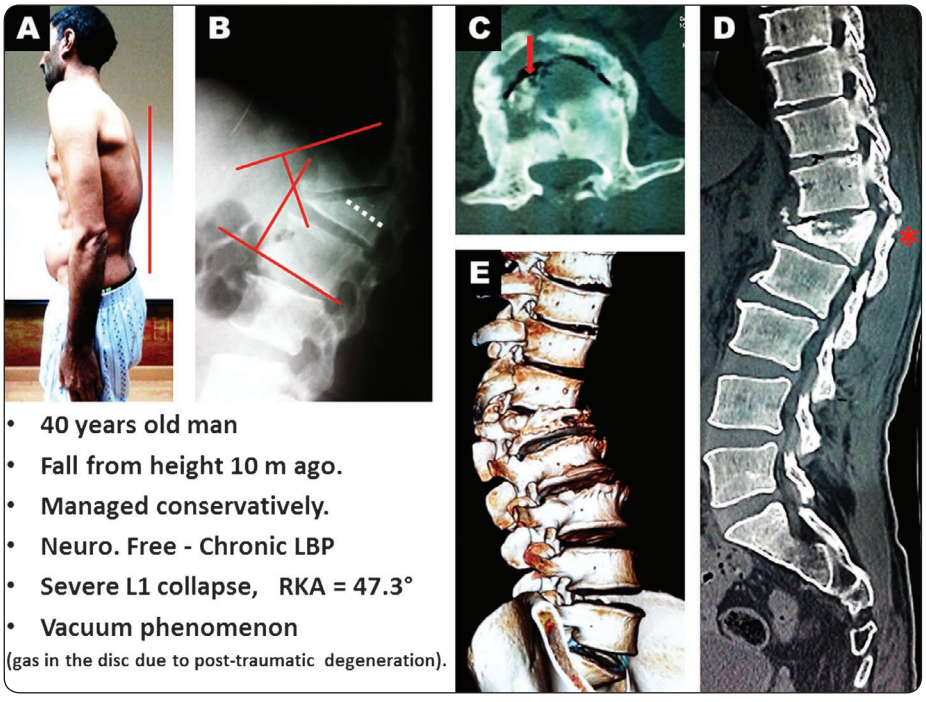

Figure 1.
Preoperative (A) Clinical photo showing the sharp angular kyphosis, (B) Lat. X-ray showing the RKA and planning of the osteotomy, (C) axial CT shows Vacuum phenomenon (gas in the disc) - red arrow, (D) and (E) Sagittal reconstruction and 3-D reformatted CT showing the deformity with manifest posterior disruption (red asterisk).

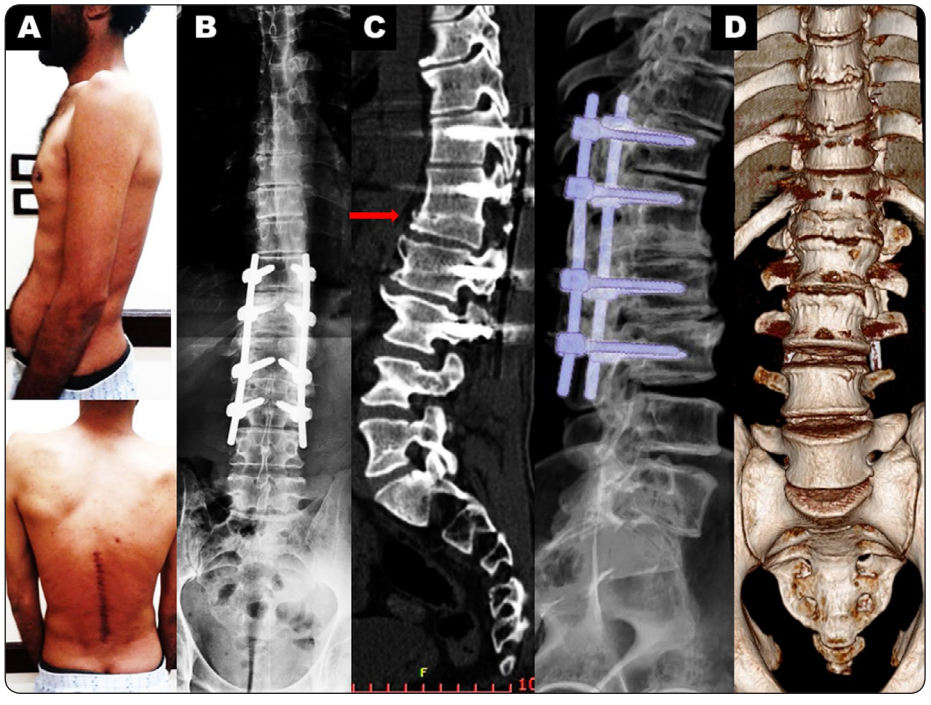

Figure 2.
3 years postoperative (A) Clinical photo showing correction of the deformity, (B) plain AP X-ray, (C) Sagittal reconstruction CT and (D) 3-D reformatted oblique and AP CT showing solid fusion, - red arrow.

Discussion

PTK represents a significant problem, both in terms of patient disability and the skills required to correct the deformity.[6,13] The kyphosis is often fixed and rigid, making surgical correction difficult and controversial.[7,18,19] Some surgeons have advocated both anterior and posterior procedures,[15] while others[5,7] have shown isolated posterior approaches to be sufficient. Although PSO is technically challenging and known to be more prone to complications, it provides satisfactory clinical and radiologic outcomes in long-term follow-up.[17] Suk et al,[16] compared the

surgical results between combined anterior-posterior procedures and posterior closing wedge osteotomy in post-traumatic kyphosis patients. They believed that PSO may achieve a larger correction, with shorter operative time and less blood loss compared with anterior-posterior surgery.

Buchowski et al,[3] showed an intraoperative or post-operative neurological deficit rate of 11.1 % (12 of 108 patients), but only 2.8 % of deficits were permanent over a 10-year period. Deficits were always unilateral and were not detected by neuromonitoring. Although it was unclear what mechanism was responsible for the development of neurologic deficits, a combination of spinal subluxation, residual dorsal impingement, and dural buckling were considered to be the main causes. It should also be noted that the disastrous result of spinal cord ischemia is equal to that of direct injury, and both can lead to paralysis, hence the maintenance of intraoperative blood pressure by sufficient fluid and blood transfusion is essential.[9] Back pain, neurological deficit and progressive deformity are the three cardinal manifestations and surgical indications of PTK.[5,7,18]

The damaged adjacent intervertebral disc which is not directly addressed in the standard PSO following trauma may at least in part responsible for back pain, neurological compression and progression of deformity through gradual settling of the disc into the fractured endplate and vertebral body. Therefore, the MPSO technique which includes partial resection of the wedged vertebra and reshaping it from cuneiform to flat, together with resection of the violated proximal disc and bone to bone fusion between the lower end plate of the proximal vertebra and the remaining part of the wedged vertebra, seems to be an appropriate alternative for the management of PTK with a severely wedged vertebra and damaged adjacent disc.

This study describes the technique of MPSO and presents clinical and radiological results that compare favorably to the standard PSO. Twelve patients (85.7%) were able to return to their previous work, while the other 2 patients were disabled due to the preoperative neurological insult (complete paraplegia in one patient and sphincteric incontinence in the other), with no major intraoperative complications or late postoperative loss of correction.

As it is a major procedure with substantial blood loss and long operative time, patients with significant medical comorbidities (such as cardiac or pulmonary disease) may not be optimal candidates.[2] In our series 2 pairs of screws were used on each side of the osteotomy, but in osteoporotic bone, more screws or even augmented screws may be necessary.

Correction of the deformity should be obtained mostly by external maneuvers, by mobilizing the patient or the operating table and minimizing direct screw compression to decrease the risk of screw pull out.

Conclusion

The surgical details and the clinical and radiological outcomes of MPSO technique for the treatment of thoracolumbar PTK have been described. Significant reduction of the kyphotic angle, few complications, and good clinical results were achieved suggesting that this procedure is relatively safe, effective and should be considered as an appropriate tool in the hand of surgeons dealing with such a challenging situation.

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الملخص العربي

دراسه طويلة المدى لتعديل فى خطوات القطع العظمى من خلال عنق الفقرة لتقويم تحدب العمود الفقرى الناتج عن كسور الفقرات

البيانات الخلفية: يعد تحدب العمود الفقرى الناتج عن كسور الفقرات الصدريه والقطنيه احد اخطر المضاعفات لهذه الاصابات, كما ان التدخل الجراحى لتقويم هذه التشوهات هو بمثابه تحد كبير. تعد عمليه القطع العظمى من خلال عنق الفقرة من اكثر العمليات استخداما, ولكنها تغفل الغضروف الذى دائما ما يكون قد اصيب بالتلف اثناء وبعد الاصابة وهنا ياتى الاسلوب المعدل فى هذه العمليه بازاله هذا الغضروف ايضا.

الغرض: استعراض نتائج تقويم تحدب العمود الفقرى الناتج عن كسور الفقرات باستخدام اسلوب معدل لعملية القطع العظمى من خلال عنق الفقرة.

تصميم الدراسه: تمت هذه الدراسه فى الفتره من فبراير 2010 الى يوليو 2014.

المرضي والطرق: تمت متابعة الحالات اكلينيكيا باستخدام مقياس الالم البصرى ومقياس دنيس للعمل، وباستخدام الاشعة عن طريق قياس زاوية التحدب قبل وبعد العملية وفى اخر متابعة.

النتائج: كان متوسط العمر للحالات 38.43 سنة وقد استغرقت الجراحة فى المتوسط 286.43 دقيقه ومتوسط النزف اثناء الجراحة كان 1017.86 مللتر. كان هناك تحسن ملحوظ فى المقياس البصرى للالم من 8.21 ± 0.77 قبل العمليه الى 2.50 ± 0.73 فى اخر متابع , كما تحسن مقياس دنيس من 4.43 ± 0.49 قبل العمليه الى 1.64 ± 1.23 فى اخر متابعه. كان هناك تحسن فى حالة القوة العصبيه من الدرجة (د) الى الدرجة (ى) فى حالة واحدة ولم يحدث تدهور فى اى حالة. زاويه التحدب تحسنت من °42.07 ± °5.28 قبل العمليه الى °2.67 بعد العمليه مع تراجع فى التحسن بمقدار °1.92 فى اخر متابعة. اشتملت المضاعفات على حالتين رتق فى الغشاء السحائى وثلاث حالات التهاب فى الجرح.

الاستنتاج: يعد التعديل فى عملية القطع العظمى من خلال عنق الفقرة لتقويم تحدب العمود الفقرى الناتج عن كسور الفقرات وسيلة جيدة للحصول على نتائج ممتازة دون زيادة فى معد المضاعفات.