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Pedicle Disc Wedge Osteotomy for the Correction of Late Post-traumatic Thoracolumbar kyphosis

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Abstract

Background Data: Late Post-traumatic thoracolumbar kyphosis can occur in a proportion of thoracolumbar fractures after inappropriate treatment. There are several surgical options to correct late post-traumatic thoracolumbar kyphosis, including anterior, posterior, and combined approaches, which are associated with varying degrees of clinical and radiological outcome success.

Purpose: The aim of this study was to assess the use of a pedicle disc wedge osteotomy for the treatment of late post-traumatic thoracolumbar kyphosis and to evaluate the radiographic findings and clinical outcomes of patients treated by this technique.

Study Design: A descriptive retrospective clinical case study.

Patients and Methods: Ten consecutive patients with symptomatic post-traumatic thoracolumbar kyphosis were treated using a pedicle disc wedge osteotomy. The mean patient age was 37.5 years. The initial trauma in all patients was Type A3, A4 according to AOSPINE thoracolumbar trauma classification. The kyphosis apex ranged from T-12 to L-2. The sagittal alignment, kyphotic angle, neurological function, Visual Analog Scale for back pain, and Oswestry Disability Index were evaluated before surgery and at follow-up.

Results: The mean preoperative regional angle was 35.5°, and the mean correction angle was 28.5°. Sagittal alignment improved with a mean correction rate of 47%. The mean surgical time was 227 minutes, and the mean intraoperative blood loss was 1380 ml. The mean Visual Analog Score for back pain improved from 8.2 to 2.0, and the Oswestry Disability Index score decreased from 56.4 to 24.4 at the last follow-up. All patients achieved bony fusion based on the presence of trabecular bone bridging at the osteotomy site.

Conclusion: The pedicle disc wedge osteotomy technique achieves satisfactory kyphosis correction with direct visualization of the circumferentially decompressed spinal cord, as well as good fusion. (2017ESJ139)

Keywords: Thoracolumbar fracture; posttraumatic thoracolumbar kyphosis; pedicle disc wedge osteotomy; deformity

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Introduction

Late post-traumatic kyphosis (PTK) is often observed after a spinal fracture. Wedging of the vertebral body associated or not with a damaged intervertebral disc and a torn posterior osseous-ligamentous complex causes the deformity.[19] Surgery is best indicated when significant pain combined with altered function is reported with a post-traumatic deformity exceeding 20° of sagittal index. Cosmetic concern must also be taken into account.[23,26]

Operative treatment of PTK is a challenge. The aim of surgery regardless of the approach includes thorough decompression of the neural elements, restoration of normal sagittal alignment, and solid bony fusion. This can be achieved through an all-anterior, all-posterior, or combined anterior–posterior procedures.[4] Posterior-only surgery may yield better therapeutic effect. In rigid sagittal plane deformities, different types of osteotomies are indicated and these include Smith-Peterson osteotomy, pedicle subtraction osteotomy, modified pedicle subtraction osteotomy or vertebral column resection in very severe and rigid cases.[4,8,13,24] Pedicle disc wedge osteotomy is an osteotomy that includes excision of the disc and partial corpectomy of the upper part of the wedged body.[20]

The aim of this study was to evaluate the clinical and radiological results of surgical treatment of late post-traumatic thoracolumbar kyphosis using the pedicle disc wedge osteotomy.

Patients and Methods

This study was designed as a retrospective clinical study of ten patients. Between January 2011 and January 2017, at Suez Canal area Hospitals (Ismailia, Egypt) a total of ten consecutive patients were included (seven men and three women). The average age was 37.5 years. They were surgically treated for symptomatic late post traumatic thoracolumbar kyphosis with a pedicle disc wedge osteotomy at our hospital.

Patient demography and perioperative data are summarized in Table 1. The average time between initial fracture and kyphosis correction was 37 months (Range, 14-66 months). All patient had been subjected to conservative treatment before presenting to our services (no previous surgical treatment), and the injured vertebra was the kyphotic apex vertebra as well as the osteotomy level. The injury level was D12 in 3 cases, L1 in 5 cases, and L2 in 2 cases. The initial trauma in all patients was Type A3, A4 according to AOSPINE thoracolumbar trauma classification.[12]

All patients complained of chronic and worsening pain in the thoracolumbar junction region. Seven patients were found to have progressive kyphosis. Four patients had conus and cauda equina neurologic impairment. Neurologic deficits were assessed according to American Spinal Injury Association (ASIA) grading system[1] and we had ASIA E, in 6 patients and ASIA D, in 4 patients.

All patients received strict and regular conservative treatment for at least 3 months before surgery and had definite surgical indications (intractable pain non-responsive to conservative treatment, progressive deformity, or progressive neurological deficits).

Operative Technique:

Following endotracheal intubation, patients were placed prone. Transverse chest and hip/thigh pads were used to maintain maximum extension of the lumbar spine to facilitate intraoperative osteoclasis throughout the osteotomy.

A posterior midline incision was made spanning from 3 levels above the fracture site to 3 levels below it, and a subperiosteal dissection was performed from the spinous process to the tip of the transverse process at all predetermined levels. With C-arm fluoroscopic guidance, monoaxial pedicle screws were then inserted 3 levels above and 2 levels below the osteotomy site.

The transpedicular disc wedge osteotomy was then performed (Figure 1). Posterior elements of the apical vertebra were removed, and epidural scarring was released carefully if necessary. An extensive posterior decompression of the dura was necessary to prevent invagination of the dura with osteotomy closure.

Meticulous subperiosteal dissection was performed down to the lateral wall of the apical vertebra. Care was taken to protect the exiting nerve

root and segmental vessels. Electric cauterization and hemostatic gauze were used to control bleeding of any segmental vessels injured during dissection. The segmental vessels may often be injured during dissection because of adhesion of inflammatory granulation tissue around the apical vertebra.

A transpedicular de-cancellation procedure, which is similar to the "egg-shell" technique, was then performed within the apical vertebral body to create a wedge resection space toward the upper segment of the damaged intervertebral disc. During this process, a probe was used to check the depth of the bone resection under fluoroscopy. When an adequate amount of the vertebral body was removed, the bilateral cortical bone of the apical vertebra was removed using a rongeur to create an operative window, which can provide sufficient space for removing the upper damaged disc. The posterior cortical bone, upper endplate, and intervertebral disc of the apical vertebral body were then removed. Temporary rods were used to prevent any uncontrolled closure of the osteotomy space, and the size of wedge space was adjusted according to the surgical plan. (Figure 2)

Finally, the wedge osteotomy space was closed gradually and smoothly while confirming no residual soft or bony compression at the resected margin. No further anterior support was needed. Adequate autograft bone was then placed in the intertransverse processes in each patient. Suction drains were placed, and the wound was closed in layers.

Postoperatively, the patients were allowed out of bed using a customized thoracolumbar orthosis 24 hours after surgery. The orthosis was used for 3 months.

Radiological Evaluation and Clinical Assessments:

Radiological evaluations were based on standing anteroposterior (AP) and lateral views, and 3D CT scans. Magnetic resonance imaging was performed to analyze the influence of surgery on the spinal canal. Kyphotic deformity was assessed on lateral radiographs using the Cobb method. Regional angles between the superior endplate of the vertebra above the apical (wedged) vertebra and the inferior endplate of the apical vertebra below were measured preoperatively, immediately after surgery, and at the final follow-up. The sagittal spine alignment was evaluated as the distance from the C-7 plumb line to the postero-superior corner of S-1. Radiological assessment of fusion at follow-up was performed based on the presence of trabecular bone bridging at the site of osteotomy.

Surgical time, operative blood loss, functional improvement, and complications, including intraoperative and early postoperative events, were assessed. Clinical outcome was measured using the Oswestry Disability Index (ODI), and back pain was assessed using a visual analog scale (VAS) preoperatively and at final follow-up. ODI was completed by the assistant surgeons from the English version that is to be translated to the patient. Neurologic deficits were assessed according to American Spinal Injury Association (ASIA) grading system [1] before and after surgery.

Results

The mean preoperative regional angle was 35.5±5.8° (Range 25-55°). Immediately after the operation, the mean regional angle was 4.5±5.1° (Range 0-10°), and it was 7±4.9° (Range 0-10°) at the last follow-up. The mean correction angle was 28.5±5.3° (Range 15–45°). The difference in the mean preoperative and postoperative regional angles was statistically significant (P=0.021). No obvious correction loss was noted at the last follow-up. The sagittal vertical axis was decreased from a preoperative mean of 2.45±0.5 cm (Range 1.5-3 cm) to the last follow-up mean of 1.15±0.2 cm (Range 1-1.5 cm) with an average correction rate of 47% (Table 2).

The mean surgical time was 227 minutes (Range 200–250 minutes), with a mean intraoperative blood loss of 1380 ml (Range 1200–1600 ml) (Table 1). Intraoperative complications included 2 dural tears, 1 nerve root injury, and 2 superficial wound infection. All dural tears were repaired primarily and did not result in adverse sequelae. The nerve root injury resulted in postsurgical radiculitis at the level of D12 and was managed conservatively by Vitamin B complex, amitriptine and alpha lipoic acid. The pain and dysthesia improved after 2 months. The

superficial wound infection was treated successfully using daily dressing and I.V. antibiotic therapy.

The mean VAS back pain score decreased from a mean of 8.2±0.9 (Range 7–9) preoperatively to 2±0.9 (Range 1–3) at the last follow-up (P=0.001), and the ODI score decreased from a mean value of 56.4±10 (Range 45–72) preoperatively to 24.4±4.8 (Range 20–30) at the last follow- up (P=0.001) (Table 3).

Two patients exhibited improved neurological function after surgery. The ASIA grade was D in 2 patients and Grade E in 8 patients at the last follow-up. The preoperative ASIA grade was D in 4 patients; 2 of these patients improved to Grade E. (Table 3).

All patients achieved bony fusion, which was confirmed based on the presence of trabecular bone bridging at the osteotomy and intertransverse processes site using radiographic evaluations, including AP and lateral views, and CT scans (Figure 2).

Table 1. Demographic and Perioperative Data

No.	Age (yrs)/ Sex	Initial injury	Kyphotic Apex/ Osteotomy Level	Initial Injury to Kyphosis Correction period (mos)	Operative Time (minutes)	Blood Loss (ml)	Hospital stay (days)	Follow-Up (mos)
1	40/M	LV1 A4	L1	66	240	1500	4	12
2	55/M	DV12 A3	D12	14	210	1200	5	100
3	47/M	LV2 A4	L2	24	230	1600	7	54
4	45/F	LV1 A3	L1	37	200	1000	5	32
5	22/M	LV1 A4	L1	44	240	1500	7	18
6	31/M	DV12 A3	D12	48	200	1200	6	10
7	47/M	LV1 A4	L1	36	250	1600	7	36
8	26/F	LV1 A3	L1	50	220	1300	6	24
9	24/M	DV12 A4	D12	24	250	1600	8	44
10	38/F	LV2 A3	L2	29	230	1300	5	77

Table 2. Radiological Outcome Study Patients (N=10)

No	Regional kyphosis Angle (°)			Sagittal vertical Axis (SVA) (CM) all + (cm)	
	Preop	Postop	Last follow up	Preop	Last follow up
1	55	10	10	2	1
2	30	0	5	1.5	1
3	40	5	10	3	1.5
4	25	5	10	2	1
5	40	5	5	3	1.5
6	25	0	0	2	1
7	40	5	10	3	1
8	30	0	0	2	1
9	35	5	10	3	1.5
10	35	10	10	3	1

Table 3. Clinical Outcome of Study Patients (N=10)

No	Preoperative			Last follow up		
	ASIA	Back pain VAS score	ODI	ASIA	Back pain VAS score	ODI
1	E	9	72	E	2	23
2	E	8	55	E	1	27
3	D	8	63	E	3	29
4	E	9	45	E	2	20
5	D	8	51	E	3	20
6	E	7	54	E	1	25
7	D	9	55	D	2	28
8	E	8	51	E	1	20
9	D	7	65	D	2	30
10	E	9	53	E	3	22

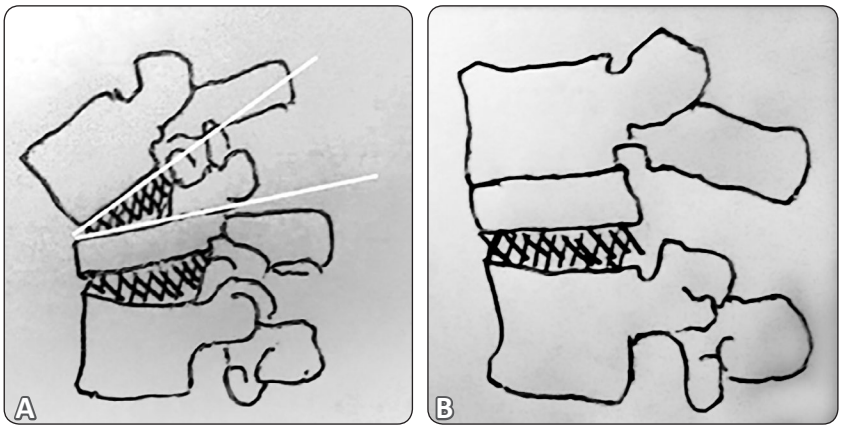

Figure 1. Transpedicular disc wedge posterior closing osteotomy. (A) Injured intervertebral disc is removed and a portion of the compressed wedge vertebra is left. (B) Anterior spinal column achieves bone-on-bone solid fusion.

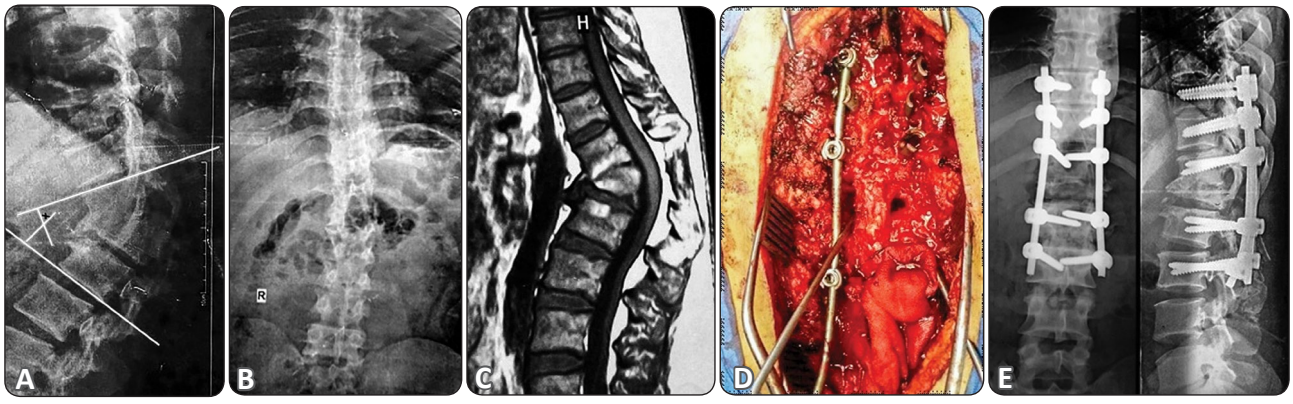

Figure 2. (A) X-ray thoracolumbar spine lateral view showing old L1 fracture complicating with post-traumatic kyphotic deformity of 55 degree. (B) X-ray thoracolumbar spine A-P view showing preserved coronal balance. (C) MRI thoracolumbar spine sagittal T1 WI showing post traumatic kyphotic deformity of the thoracolumbar junction with preserved CSF signals behind the apex of the deformity indicating long standing deformity development. (D) All posterior approach exposure shows pedicle screws inserted 3 levels above and 2 levels below the target level, temporary rod to the left, suction is in osteotomy cavity. (E,F) X-ray thoracolumbar spine AP, lateral views showing postoperative stabilization of the thoracolumbar spine with postoperative kyphotic angle of 10°.

Discussion

We have reported the results of 10 patients with late post-traumatic thoracolumbar kyphotic deformity treated with a pedicle disc closing wedge osteotomy. Good results were achieved in all patients without the risks inherent in the anterior approach. Vertebral fractures in thoracolumbar junction region are the most frequent spinal injuries.[23] When these fractures are inadequately treated, there is a tendency for the injured vertebra to gradually collapse because of the direct force on the anterior and middle column of the spine.[4,18]

The pain associated with post-traumatic kyphosis may be from the site of the deformity itself, the injured disc, a bony nonunion, or the lordotic compensation above and below the deformity site where added stresses are placed on the respective facet joints.[5] In addition, post-traumatic tethered spinal cord as a result of dural adhesions can cause severe pain, and the precise origin of the pain is frequently difficult to identify in these cases.[15]

In patients with late post-traumatic kyphosis, the kyphosis is often fixed and rigid, and the correction is difficult. In the presence of healed and contracted anterior soft tissue, surgical correction by posterior spinal decompression, such as Smith-Peterson osteotomy, is often not successful.[14] In these cases, the spinal cord cannot be adequately decompressed through traditional posterior lamina decompression because the compression is located anteriorly.[7,21] If surgery is restricted to an anterior approach,

correction of the deformity is often hindered by lack of access to posterior structures. Thus, there is significant debate over the ideal surgical approach to the correction of the deformity.[4,6,9,13,16,24]

The combination of circumferential spinal decompression and safe correction of the vertebral column in a single posterior approach was advocated by Gertzbein and Harris[8] for the correction of posttraumatic kyphosis, and the authors showed that an average of 30˚degree sagittal correction could be achieved by means of a wedge osteotomy and the Harrington system. Bohm et al,[3] combined dorsal decompression and fixation and ventral osteotomy and grafting and achieved a mean angular correction of 22.5 degrees in 40 patients. However, a two-stage or three-stage supine-prone-supine procedure is associated with more incisions, complications, and blood loss. Kawahara et al,[11] described a technique of circumspinal decompression and correction osteotomy using a single posterior approach for the correction of angular kyphotic deformity. Anterior decompression of the spinal cord is possible by costotransversectomy, and patients with or without neurologic deficits are considered as suitable candidates for the procedure. In the seven patients treated, localized kyphosis was reduced from an average of 67 degrees to 18 degrees at 2.2 years to 7.5 years follow-up, and sagittal alignment from T1 to the sacrum was improved. Wu et al,[26] also reported a single-staged posterior approach, posterior decancellation osteotomy, and achieved an average correction of 38.8 degrees in rigid posttraumatic kyphosis patients.

Suk et al,[22] compared the surgical results between combined AP procedures and posterior closing wedge osteotomy in posttraumatic kyphosis patients and believed that a one-stage single posterior (pedicle subtraction osteotomy) approach may result in better correction, shorter operative time, and less blood loss compared with AP surgery. Ayberk et al.[2] reported a novel technique of three-column stabilization via a posterior approach alone using transpedicular placement of a distractable cage with transpedicular screw fixation. Desired stabilization was achieved in the eight patients.

In comparison to our study Hu et al,[10] studied 46 consecutive patients experiencing post-traumatic thoracolumbar kyphosis who underwent one-stage pedicle subtraction osteotomy and disc resection with cage placement and long-segment fixation. They achieved comparable clinical and radiological results to this study.

Reviewing the magnetic resonance imaging performed on patients in our study, we can find that the pedicle region and the posterior part of the upper endplate and disc are usually the apex of a sharp angular protrusion, which compresses on the spinal cord. When a regular pedicle subtraction osteotomy is attempted, it is inevitable that the collapsed upper endplate is removed, and the lower surface of the upper level injured disc is exposed, which may have fallen into the damaged upper endplate. When you close the space, damaged upper disc will rest on the cancellous bone of the remaining vertebra; thus, the disc may still fall into the remaining vertebra and induce back pain. Furthermore, bony fusion is difficult to achieve in this situation. Therefore, we modified the regular wedge closing osteotomy technique to remove the injured upper endplate and upper disc, so that anterior decompression can be achieved directly and reasonably. As the rectangle lower half of the injured vertebra remains, a larger interspace is achieved, which allows more effective kyphosis correction. Moreover, the inferior bony endplate of the upper vertebra is set on the cancellous bone of the remaining vertebra to achieve solid fusion, which is of great importance for the relief of back pain.

Conclusion

The pedicle disc wedge osteotomy technique achieves satisfactory kyphosis correction with direct visualization of the circumferentially decompressed spinal cord, as well as good fusion.

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الملخص العربي

التعديل الخلفي مع إغلاق إسفين العظم لتصحيح تحدب الفقرات الصدرية القطنية المتأخر

البيانات الخلفية: قد ينتج انحناء وتحدب في الفقرات الصدرية القطنية في بعض مرضى كسور الفقرات الصدرية القطنية الذين لا يعالجون بطريقه صحيحة. يوجد العديد من الخيارات الجراحية لعلاج هذا الانحناء سواء عن طريق الجراحة من الأمام أو الخلف أو الاثنين معا. تقترح هذه الدراسة جراحه تعديل خلفي مع إغلاق إسفين العظم لتصحيح تحدب الفقرات الصدرية القطنية المتأخر.

الغرض: توضيح النتائج الجراحية السريرية والإشعاعية لجراحة التعديل الخلفي مع إغلاق إسفين العظم لتصحيح تحدب الفقرات الصدرية القطنية المتأخر

تصميم الدراسة: دراسه لحالات أكلينيكية على 10 مرضى يعانون من تحدب الفقرات الصدرية القطنية المتأخر .

المرضي والطرق: تم إجراء الجراحات من 2011 إلى 2017 . كان متوسط العمر 37 عاما وكانت قمه التحدب في الفقرة القطنية الأولى في خمسة مرضى . تم قياس زوايا التحدب في العمود الفقري وملاحظه مقدار الألم على المضاهي البصري والتحسن في الوظائف العصبية والنشاط اليومي للمريض .

النتائج: أوضحت النتائج أن متوسط زاويه التحدب قبل الجراحة كانت 35 درجه وتحسنت بمقدار 28 درجه بعد الجراحة . كان متوسط زمن الجراحة 227 درجه ومتوسط فقد الدم 1380 درجه. تحسن الألم بدرجه كبيره جدا في المرضى وكذلك النشاط اليومي . اظهر جميع المرضى التحام للعظام بعد الجراحة.

الاستنتاج: يتضح من هذه الدراسة أن النتائج السريرية والإشعاعية لجراحه التعديل الخلفي مع إغلاق إسفين العظم لتصحيح تحدب الفقرات الصدرية القطنية المتأخر هي نتائج جيدة واظهر كل المرضى تحسن في مقاييس الألم والنشاط اليومي.