Pedicle subtraction osteotomy for the treatment of posttraumatic thoracolumbar kyphosis

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Background
Posttraumatic thoracolumbar deformity is a common complication of spinal trauma after conservative treatment or after inadequate surgical management. The goals of surgery are to decompress the neural elements and restore sagittal and coronal balance and to optimize the chances for successful fusion. These goals can be achieved through an all-anterior, all-posterior, or a combined anterior and posterior approach.
Patients and methods
A total of 13 patients with symptomatic posttraumatic thoracolumbar kyphosis were treated with pedicle subtraction osteotomy. The mean age of the patients was 35.3 years. The injury level was L1 in eight cases, L2 in three cases, and T12 in two cases. Of the 13 patients, eight had been managed conservatively and five had initial posterior pedicle screw fixation. Most patients (69.2%) complained of chronic and worsening pain in the thoracolumbar junction region, 38.4% were found to have progressive kyphosis, and none had conus or cauda neurologic impingement.
Results
The mean surgical time was 206 min, with a mean intraoperative blood loss of 700.7 ml. All patients completed follow-up for at least 2 years. Complications were encountered in six cases. The average Cobb angle decreased from 38.4° preoperatively to 2.3° after surgery. The mean visual analog scale for back pain decreased from 54.4 preoperatively to 18.5 at the last follow-up, and the Oswestry disability index score changed from a mean value of 53.07 preoperatively to 24.5 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 subtraction osteotomy achieves satisfactory kyphosis correction and good fusion with less blood loss and complications than other approaches.

Keywords:
pedicle subtraction osteotomy, posttraumatic kyphosis, spinal balance

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Introduction

Posttraumatic thoracolumbar deformity is a common complication of spinal trauma and is a great challenge to spinal surgeons. It can occur in patients after conservative treatment or after inadequate surgical management [1].

Successful treatment of posttraumatic spinal deformity is dependent on careful patient selection and appropriate surgical intervention. Surgery should be considered in the presence of significant or progressive deformity, increasing back and/or leg pain, pseudarthrosis, and increasing neurological deficit. The goals of surgery are to decompress the neural elements and restore sagittal and coronal balance and to optimize the chances for successful fusion. These goals can be achieved through an all-anterior, all-posterior, or a combined anterior and posterior approach [2].

The aim of this prospective study was to evaluate the radiographic and clinical outcome of patients treated with pedicle subtraction osteotomy for posttraumatic kyphosis.

Patients and methods

From March 2010 to March 2012, 13 patients (nine men and four women) with an average age of 35.3 years (range, 21–48 years) were surgically treated for symptomatic posttraumatic thoracolumbar kyphosis with pedicle subtraction osteotomy at Zagazig University Hospital. All 13 patients completed

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Table 1 Patient demographics

Cases	Sex	Age (years)	Type of injury	Previous treatment
1	M	32	T12: anterior column compression, no spinal cord injury	Brace for 3 months
2	M	30	L1: anterior column and middle column compression, ASIA score (C)	Laminectomy and pedicle screw fixation (4 pedicle screws)
3	M	21	L1: anterior column compression, no spinal cord injury	Bed rest, immobilization, and symptomatic treatment
4	M	41	L1: anterior column compression, no spinal cord injury	Brace for 3 months
5	F	39	L2: anterior column compression without spinal cord injury	Bed rest, immobilization, and symptomatic treatment
6	M	39	L1: anterior column compression, no spinal cord injury	Brace for 3 months
7	F	44	L1: anterior column and middle column compression, ASIA score (D)	Bed rest, immobilization, and symptomatic treatment
8	M	35	L2: anterior column and middle column compression, ASIA (D)	Pedicle screw fixation (4 pedicle screws)
9	M	27	L1: anterior column compression. No spinal cord injury	Brace for 3 months
10	M	31	L1: anterior column compression, no spinal cord injury	Brace for 3 months
11	M	37	L2: anterior column and middle column compression without significant neural injury	Pedicle screw fixation (4 pedicle screws)
12	F	48	T12: anterior column and middle column compression without significant neural injury	Pedicle screw fixation (4 pedicle screws)
13	F	35	L1: anterior column and middle column compression without significant neural injury	Pedicle screw fixation (4 pedicle screws)

ASIA, Asia Spinal Injury Association; F, female; M, male.

follow-up of at least 2 years. Patient data are summarized in Table 1.

The average time between initial fracture and kyphosis correction was 15.5 months (range, 8–36 months).

The injury level was L1 in eight cases, L2 in three cases, and T12 in two cases.

Of the 13 patients, eight had been managed conservatively and five had initial posterior pedicle screw fixation with (one case) or without posterior decompression (four cases).

Most patients (nine (69.2%) of 13) complained of chronic and worsening pain in the thoracolumbar region, and five (38.4%) of 13 were found to have progressive kyphosis. Neurologic deficits were assessed according to Asia Spinal Injury Association (ASIA) grading system [3]: ASIA E, 10 cases; ASIA D, two cases; and ASIA C, one case.

Surgical technique

Under general anesthesia, the patient was placed prone on a radiolucent operating table. A standard posterior midline incision was made extending from two levels above the fracture site to two levels below it. Pedicle screws were inserted into the two cranial and two caudal vertebrae. A laminectomy was performed at the planned osteotomy level. The pedicles were then resected on both sides flush with the vertebral body. Care was taken to preserve the exiting nerve root running along the medial and inferior surfaces of the pedicle. A partial resection of the posterior wall of the vertebral body was performed, followed by a decancellation of a V-shaped wedge of bone.

The osteotomy was finished by resection of the appropriate amount of bone from the lateral part of the vertebral body bilaterally. The anterior cortex of the vertebral body was preserved to prevent dislocation of the osteotomy during closure of the wedge. The spine was then reconstructed by securing rods to the pedicle screws. The final step was to close the osteotomy. This was accomplished by cantilevering the spine (eight cases), or hyperextending the patient's chest and lower extremities may accomplish closure (five cases). In this way, closure of the osteotomy site was achieved with direct bone on bone contact. When the construct is complete and the osteotomy is closed on both sides, the spinal canal is dissected, with a nerve hook to confirm that there is no dorsal compression of the dural sac.

In this study, polyaxial screws of different diameters were used. Posterolateral bone grafting was routinely performed at the region of posterior fixation (all cases).

A drainage tube is put into the operating field and the wound was closed in layers.

Postoperatively, the patients were put in a thoracolumbosacral orthosis and walking was permitted

soon after the removal of drainage in neurologically intact patients. Sitting or walking in neurologically deficit patients was dependent on the state of neural recovery. The Thoraco-Lumbar Spine Orthosis (TLSO) was preserved for 3 months.

Radiologic evaluation and clinical assessments

Radiographic evaluation was based on anteroposterior and lateral views, flexion and extension lateral views, and three-dimensional computed tomography scans. MRI was performed for all patients in the study. Kyphotic deformity was assessed on lateral radiographs using the Cobb method [4]. It was measured preoperatively, immediately after surgery, and at the final follow-up. Radiologic assessment of fusion at follow-up was based on the presence of trabecular bone bridging at the osteotomy site as described by Brantigan and Steffee [5].

Surgical time, operative and postoperative blood loss, functional improvement, and complications, including intraoperative and early postoperative, were recorded. Clinical outcome was measured by Oswestry disability index score [6], and back pain was assessed using a visual analog scale preoperatively and at the final follow-up.

Results

Preoperative and postoperative data of the 13 patients are summarized in Table 2. The mean patient age at the time of surgery was 35.3 years. The mean surgical time was 206 min (range, 180–280 min), with a mean intraoperative blood loss of 700.7 ml (range, 420–1500 ml). The mean blood loss from drainage postoperatively was 343.8 ml (range, 250–500 ml), and the drainage lasted a mean of 3.5 days (range, 2–4 days). All patients completed follow-up of at least 2 years.

Complications were encountered in six (46.15%) cases and included intraoperative dural tears in two patients. One tear was successfully repaired intraoperatively, and the other patient experienced a persistent spinal fluid leak that required further surgical revision and was finally controlled 3 weeks postoperatively. There was one case of wound infection that required debridement. Unilateral anterior thigh numbness and weakness occurred in three patients postoperatively, and all cases resolved spontaneously within 1 month.

The average Cobb angle decreased from 38.4° (range, 28–60°) preoperatively to 2.3° (range, 0–6°) after surgery, and the difference was statistically significant ($P<0.001$).

The mean visual analog scale for back pain decreased from a value of 54.4 (range, 34–82) preoperatively to 18.5 (range, 9–34) at the last follow-up ($P<0.001$), and the Oswestry disability index score changed from a mean value of 53.07 (range, 30–87) preoperatively to 24.5 (range, 10–52) at the last follow-up ($P<0.001$).

All patients achieved bony fusion based on the presence of trabecular bone bridging at the osteotomy site [5] (Figs 1 and 2).

Discussion

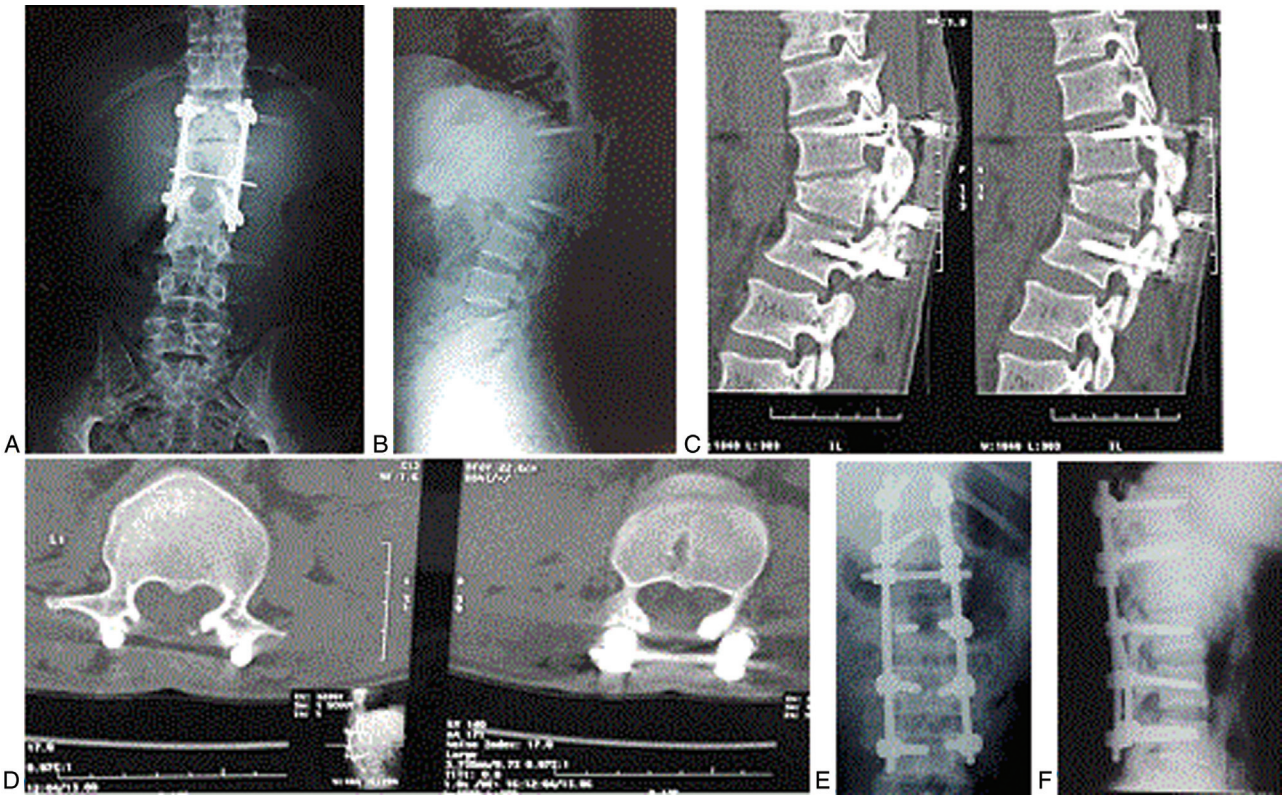
Fractures in thoracolumbar junction region are the most frequent spinal column injuries [7].

Table 2 Preoperative and postoperative patient data

Cases	Preoperative				2 years postoperative follow up				*P* (compared with preoperative value)
	ASIA	ODI	VAS	Cobb's angle (deg.)	ASIA	ODI	VAS	Cobb's angle (deg.)	
1	E	59	53	29	E	17	21	0	
2	C	87	82	53	D	46	31	1	
3	E	34	67	32	E	10	15	2	
4	E	44	51	30	E	19	14	1	
5	E	42	35	28	E	16	13	5	
6	E	37	54	30	E	17	16	4	
7	D	63	59	41	D	27	13	3	
8	D	72	64	58	E	18	20	6	
9	E	30	46	28	E	12	9	2	
10	E	39	34	29	E	42	21	0	
11	E	40	36	33	E	52	9	2	
12	E	73	65	60	E	20	25	5	
13	E	70	62	49	E	23	34	0	
Mean±SD		53.07	54.4	38.4		24.5	18.5	2.3	<0.001*

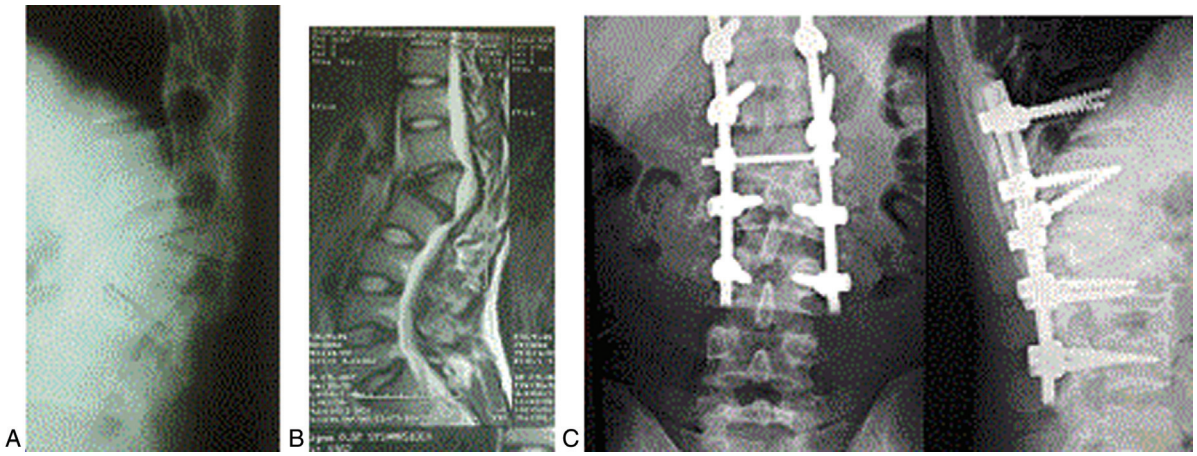
ASIA, Asia Spinal Injury Association; ODI, Oswestry disability index; VAS, visual analog scale. **P* value less than 0.05, statistical significant using paired *t* test.

Figure 1



A 30-year-old male patient with L1 fracture. Preoperative (a) Anteroposterior radiography, (b) lateral radiography, (c) sagittal and (d) axial computed tomography cuts, (e) postoperative radiography anteroposterior radiography, and (f) lateral radiography.

Figure 2



A 41-year-old male patient with L1 fracture. Preoperative (a) lateral radiography, (b) sagittal MRI, and (c) postoperative radiography anteroposterior and lateral radiography.

Posttraumatic deformities can be treated with both conservative and surgical management; however, when 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. In addition, posterior muscle strength becomes weaker with age, thus worsening the collapse [8]. Posttraumatic kyphosis in this region may affect the conus or cauda equina or both through nerve root compression or impairment of blood circulation.

Patients treated conservatively often experience chronic back pain because of the gradual increase of kyphosis, which causes further damage to the posterior soft tissues. A study indicated that among posttraumatic kyphosis patients, 94% have continuous back or lower

extremity pain, 46% will have worsening of the kyphosis, and in 36%, the vertebrae are unstable based on radiographic studies [9].

The pain associated with the kyphosis deformity 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 [10].

In addition, posttraumatic 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 [11].

In cases of posttraumatic 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 [12].

In these cases, the spinal cord cannot be adequately decompressed through traditional posterior decompression because the compression is located anteriorly [13,14].

The combination of decompression and safe correction of the vertebral column in a single posterior approach was advocated by Gertzbein and Harris [15] for the correction of posttraumatic kyphosis, and the authors showed that an average of 30° sagittal correction could be achieved by means of a wedge osteotomy and the Harrington system.Bohm *et al.* [16] combined dorsal decompression and fixation and ventral osteotomy and grafting and achieved a mean angular correction of 22.5° in 40 patients.

Wu *et al.* [17] also reported a single-staged posterior approach, posterior decancellation osteotomy, and achieved an average correction of 38.8° in rigid posttraumatic kyphosis patients.

Suk *et al.* [18] compared the surgical results between combined anteroposterior 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 anteroposterior surgery.

Ayberk *et al.* [19] 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 treated with the absence of the risks associated with an anterior approach.

We have reported the results of 13 patients with symptomatic posttraumatic thoracolumbar deformities treated with a posterior closing wedge osteotomy. Good results were achieved in all patients without the risks inherent in an anterior approach. Favorable results in terms of neurological recovery and improvement in overall functional status has been reported for our patients.

Although many surgeons allow an immediate mobilization without any orthosis, postoperative protection with an orthosis is our routine practice.

The purpose is not a strict limitation of the patient's activity or immobilization, but an appropriate control of the range of motion to ensure soft-tissue healing. We have also tried immediate mobilization without any limitation; however, most Egyptian patients lack good exercise habits and physical conditioning, and they do not want to perform rehabilitation exercises for fear of injury to the surgical site.

In other words, they think that the use of an orthosis will assist in their healing and recovery.

Conclusion

The pedicle subtraction osteotomy achieves satisfactory kyphosis correction and good fusion with less blood loss and complications than other approaches. Therefore, it is an alternative method in patients with posttraumatic kyphosis.

Successful outcomes depend on a number of factors including proper patient selection and a proper understanding of biomechanical principles, technical ability, and experience.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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