Single-Stage Transpedicular Approach for Circumferential Arthrodesis in Traumatic Lumbar Vertebral Body Burst Fractures

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Indian J Neurotrauma 2019;16:14–20

Abstract

Background Traumatic vertebral burst fractures can be surgically approached via different approaches (anterior/posterior, or combined). Posterior transpedicular approach (PTA) is a posterior approach that has the advantage of achieving circumferential arthrodesis via single posterior-only approach. The purpose of this study was to analyze our experience with PTA in management of traumatic lumbar burst fractures (TLBFs).

Methods All consecutive patients with TLBFs managed with PTA over 3 years' duration were included in this retrospective study. Correction of kyphotic deformity and change in neurologic status were analyzed to assess outcome. Cobb's angle and American Spinal Injury Association (ASIA) grade were used for this purpose.

Results There were 12 males and 8 females. Five patients had complete (ASIA-A) while 12 had incomplete injury. The mean preoperative Cobb's angle was 14.23 degrees that improved to–3.21 degrees postoperatively (mean kyphosis correction: 17.44 degrees). None of the patients developed iatrogenic nerve root injury. There was no perioperative mortality. The mean Cobb's angle was 1.45 degrees at 36 months' follow-up. Four patients developed cage subsidence but none required revision surgery. Postoperatively, 13 (65%) patients showed neurologic improvement and none deteriorated. The average ASIA score improved from 2.82 to 4.23. A fusion rate of 96% was observed at last follow-up.

Conclusion The advantages of PTA including sense of familiarity with posterior approach among spine surgeons, lesser approach-related morbidity, and results comparable to anterior/combined approaches, make the PTA an attractive option for managing TLBFs. Although technically difficult, it can be successfully used for circumferential arthrodesis in the lumbar region without sacrificing nerve roots.

Keywords
- traumatic lumbar burst fractures
- corpectomy
- circumferential arthrodesis
- posterior transpedicular approach
- single-stage posterior only approach

Introduction

Traumatic lumbar fractures account for approximately 44% of all traumatic vertebral fractures.[1] Traumatic lumbar burst fractures (TLBFs) may cause canal compromise and neural compression from fractured fragments as well as kyphotic deformity. The goal of surgical management in such fractures is to achieve adequate decompression of spinal canal,

received
September 15, 2019
accepted
September 16, 2019

DOI https://doi.org/10.1055/s-0039-1700366
ISSN 0973-0508.

correction of kyphotic deformity, and spinal stabilization. This requires corpectomy followed by anterior column reconstruction along with pedicle screws and rod (PSR) insertion to achieve circumferential arthrodesis. Posterior transpedicular approach (PTA) that includes transpedicular corpectomy and anterior column reconstruction via a posterior-only approach, combined with PSR fixation, can achieve canal decompression and circumferential arthrodesis via single posterior approach (PA).[2-16] PTA has mostly been described for nontraumatic vertebral pathologies including primary or metastatic vertebral tumors, especially of thoracic spine where the thoracic nerves can be sacrificed with impunity.[3,4,7,9,12,14,17] However, transpedicular corpectomy for TLBFs is technically challenging because of the indispensable lumbar nerve roots. In this retrospective study, we present our experience in managing TLBFs using PTA. The surgical technique, results of surgery, complications, patient outcome, and pertinent literature are discussed in detail.

Materials and Methods

This was a retrospective study conducted at a tertiary care trauma center. We included 20 patients with TLBFs who underwent circumferential arthrodesis via PTA over a period of 3 years. Patient's casualty/inpatient records, radiological investigations (magnetic resonance imaging [MRI] and noncontrast computed tomography [NCCT]), operation notes, and outpatient records were scrutinized to collate data. Demographic details, pre- and postoperative neurologic status, preoperative deformity, intraoperative details, duration of hospital stay, deformity correction, and bony fusion at last follow-up were analyzed.

Preoperative Assessment

A detailed preoperative neurologic examination was done and recorded. Patient's neurologic status was then scored using the American Spinal Injury Association (ASIA) scoring system.[18] All patients underwent preoperative spine computed tomography (CT) scan to look for type of fracture and the extent of canal compromise. Cobb's angle,[19] defined as the angle between lines drawn along superior endplate of unaffected vertebral body (VB) rostral to deformity, and inferior endplate of unaffected VB caudal to deformity, was used to quantify deformity. Most patients also underwent preoperative MRI for assessing the presence of disc prolapse and injury/compression of spinal cord/nerve roots. All patients included in the study either had posttraumatic kyphosis or a fracture fragment impinging on the cord. Thoracolumbar Injury Classification and Severity (TLICS) score was used to decide between conservative or surgical management.

Operative Procedure

After positioning the patient prone, posterior bony elements were exposed and bilateral laminectomies of fractured vertebra were performed to decompress the thecal sac. Pedicle screws were inserted under C-arm/O-arm guidance and a rod was placed on the right side and distracted to open up the space for corpectomy. The superior and inferior facets surrounding the pedicle of the VB to be resected were drilled to expose the pedicle and nerve root. Initially, pedicle on the left side was removed followed by corpectomy using high-speed drill, curettes, and rongeurs. Posterior longitudinal ligament was preserved to prevent thecal sac damage from drill/instruments. Majority of VB could be removed through unilateral transpedicular route, while the remainder was removed through contralateral pedicle. Resection of cortical bone immediately behind the great vessels was not done to avoid vascular injury.[8,9] The exiting nerve roots at the corpectomy level were preserved. Anterior reconstruction was performed by inserting titanium expandable/mesh cages filled with autologous bone. For safe insertion of cage, roots were mobilized and the cage was inserted along the axis of the nerve roots and then turned in situ to lie along the long axis of the spine. The collapsed cage was positioned with caudal portion of the cage in contact with endplate of the caudal vertebra, while rostral portion of the cage telescoped superiorly with expansion. Mesh cage was cut in appropriate size and positioned by placing the inferior end of the cage against superior endplate of the VB below, then the cage was rotated and superior aspect of the cage was gently tapped against inferior endplate of the VB above. After cage placement, compression was applied across posterior pedicle screw fixation so that the cage snugly fits and remains in contact with endplates on either side. The posterior bony elements of the vertebrae above and below were then decorticated with drill to achieve raw bony surface and then covered with locally harvested bone fragments. The removal of all three columns at the fracture site and distraction achieved by placing an interbody cage made it feasible to achieve restoration of height and deformity correction (►**Figs. 1**–**3**).

Postoperative Assessment

A detailed postoperative neurologic examination was done and scored using the ASIA scoring system at each follow-up. Neurologic status was categorized as improved, stable, or worsened based upon the ASIA grade change. Postoperative NCCT was done in all patients before discharge and then during follow-up. Cobb's angle was measured on postoperative and follow-up NCCT. Also, CT scans were analyzed for fusion, subsidence of cage, or implant failure. Bony fusion was evaluated using radiographic criteria, that is, formation of bridging trabecular bone and absence of a dark halo around the implant or implant fracture.[20,21]

Results

A total of 20 patients underwent circumferential arthrodesis via PTA during the study period. The age range of patients was 13 to 52 years with an average of 26.1 years. There were 12 males and 8 females. The mode of injury was road traffic accident in 15, fall from height in 3, and fall of a heavy object in 2 patients. L1 was the most common vertebra involved in 13 (65%) patients followed by L2 in 4 (20%) patients (►**Table 1**).

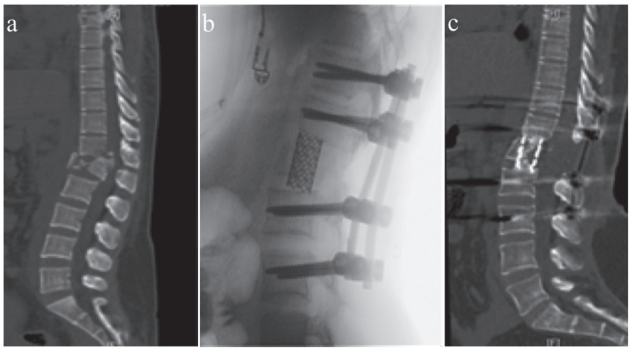

Fig. 1 Preoperative noncontrast computed tomography (NCCT) of the dorsolumbar region, mid-sagittal section shows burst fracture of L1 vertebral body with canal compromise and kyphotic deformity (**A**). Patient underwent corpectomy and circumferential arthrodesis via posterior transpedicular approach (PTA) with titanium mesh interbody cage placement and long segment pedicle screw fixation (**B**). Immediate postoperative X-ray (**B**) and follow-up NCCT scan (**C**; 12 months) show correction and maintenance of kyphotic correction. The spinal canal has been well decompressed (**C**).

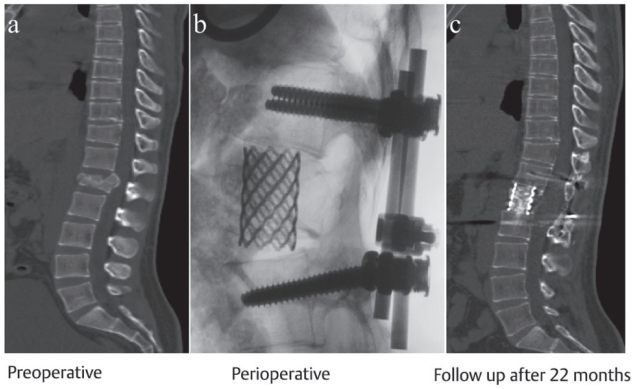

Fig. 2 Preoperative noncontrast computed tomography (NCCT) shows L1 vertebral body burst fracture with canal compromise (**A**). Patient underwent circumferential arthrodesis via posterior transpedicular approach (PTA). A titanium mesh cage placement and short segment pedicle screw fixation achieved good kyphosis correction (**B**). A follow-up NCCT at 22 months revealed well decompressed spinal canal and formation of bridging bone across the mesh cage (**C**).

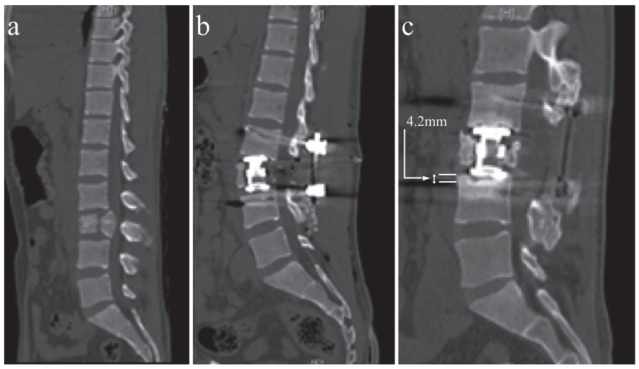

Fig. 3 Preoperative noncontrast computed tomography (NCCT) shows L3 vertebral burst fracture, canal compromise, and mild kyphotic deformity (**A**). Patient underwent corpectomy, expandable interbody cage placement, and short segment posterior fixation (**B**). Immediate postoperative NCCT showed well decompressed spinal canal and correction of lumbar lordosis (**B**). Follow-up scan at 18 months revealed cage subsidence of 4.2 mm and mild loss of kyphosis correction.

Preoperative Neurologic Status (►Table 1)

Among 20 patients with available follow-up, 5 (25%) belonged to ASIA A with complete loss of motor/sensory and bowel/bladder function below the level of injury. Twelve (60%) patients had incomplete neurologic deficits (ASIA C and D), while 2 (10%) patients had only sensations intact with paraplegia (ASIA B). Only 1 (5%) patient was neurologically intact (ASIA E) preoperatively. All the patients had a TLICS score of ≥ 4 and thus were managed surgically.

Preoperative Deformity (►Fig. 4A, B)

Preoperative Cobb's angle was calculated in all patients. Most of the patients presented with kyphotic deformity of 10 to 20 degrees and the mean preoperative kyphotic deformity was 14.23 degrees.

Operative Parameters and Perioperative Complications (►Table 2)

The mean duration of surgery was 366 minutes (range: 240–600 minutes) and mean blood loss was 1,200 mL (range: 500–4,500 mL). Short segment (one segment cephalad and one caudal to level of corpectomy) fixation was done in 13 patients while 7 patients underwent long segment (≥ 2) fixation. The decision of short/long segment fusion was based on the surgeon's preference. The expandable cage was used in 14 and mesh cage in 6 patients. Iatrogenic durotomies occurred in two patients while dural tears secondary to trauma were found in five patients. Preexistent nerve root injury

Table 1 Patient characteristics and preoperative parameters

Parameter		Total
No. of patients		20
Mean age (13–52 y)		26.1
Gender	Male	12
	Female	8
Mode of injury	RTA	15
	Fall	3
	Others	2
Lumbar vertebral level involved	L1	13
	L2	4
	L3	2
	L4	0
	L5	1
ASIA score (preoperative)	A	5
	B	2
	C	7
	D	5
	E	1
Injury to surgery interval (1 d–2 y)		14 d (median)

Abbreviations: ASIA, American Spinal Injury Association; RTA, road traffic accident.

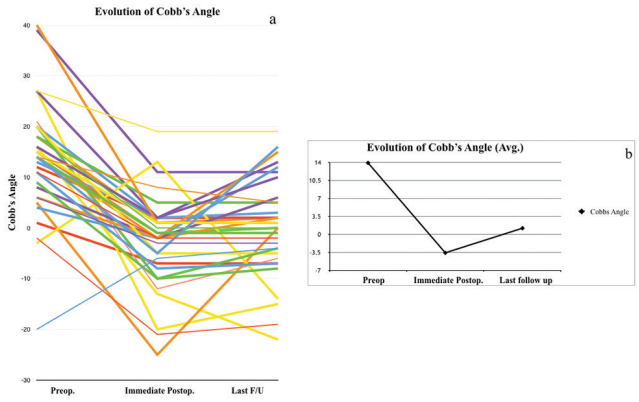

Fig. 4 The line diagram showing the evolution of Cobb's angles of individual patients immediately after surgery and at last follow-up (**A**). The changes in average Cobb's angle immediately after surgery and at last follow-up are also shown (**B**).

Table 2 Operative data and perioperative complications

Parameter		Total
No. of patients		20
Mean duration of surgery (240–660 min)		366
Mean EBL (500–5,000 mL)		1,200
Levels fixed	Single	13
	≥ 2 levels	7
Type of cage	Mesh	14
	Expandable	6
Durotomies	Total	7
	Traumatic	5
	Iatrogenic	2
Nerve root injury	Total	2
	Traumatic	2
	Iatrogenic	0
Imaging used	O-arm	16
	C-arm	4
Postoperative complications	Mortality	0
	Wound dehiscence	2
Mean postoperative hospital stay (2–24 d)		6.24

Abbreviation: EBL, estimated blood loss.

attributable to trauma was encountered in two patients and none suffered iatrogenic injury. Postoperatively, two patients had surgical wound infection with dehiscence, which required debridement and resuturing. There was no perioperative mortality or postoperative neurologic deterioration. The mean postoperative hospital stay was 6.28 (2–24) days (►**Table 2**).

Neurologic Status at Last Follow-Up

Out of 20 patients, 13 (65%) showed neurologic improvement after surgery. Among these 13 patients, 7 (53.8%) had improvement by one ASIA grade, 4 (30.7%) improved by 2 grades, and 2 (15.4%) patients improved by 3 grades. The improvement in motor functions was observed in 12 (60%) patients. Eleven (55%) patients had preoperative bladder and bowel disturbances, which improved in three (15%) patients. The average ASIA score improved from 2.82 to 4.23.

Status of Deformity at Last Follow-Up

(►Fig. 4A, B)

The Cobb's angle of lordotic spine after deformity correction was marked as negative to determine the extent of correction. The mean preoperative and postoperative Cobb's angles were 14.23 and–3.21 degrees, respectively, thus achieving a mean Cobb's angle correction of 17.44 degrees. Over a mean follow-up of 36 months, there was a loss of lordosis to some extent in some patients with cage subsidence seen in 4 patients. The mean Cobb's angle during follow-up was 1.45 degrees, thus resulting in loss of 4.66 degrees.

Fusion: Over a mean follow-up of approximately 36 months, 96% patients achieved bony fusion.

Delayed complications: During follow-up scans, 4 patients had cage subsidence of > 2.5 mm (►**Fig. 3c**) with an average subsidence of 6.8 mm. These patients complained of mild backache which was controlled with analgesics and none of them required revision surgery.

Discussion

Though optimal treatment for TLBFs, in absence of neurologic deficits or significant instability, still remains a matter of debate,[22-25] surgical decompression and fixation is usually recommended for patients with significant deformity and in those with neurologic deficits due to canal compromise.[17,26] Surgical management in these patients requires corpectomy and spinal canal decompression followed by circumferential arthrodesis. The choice of surgical approach (anterior/combined vs. posterior), however, remains a matter of debate.[17,26-33]

Anterior approach (AA), first described by Burns[34] in 1933, has been used by many authors for various pathological conditions of spine.[2,26,28-32,35-38] Though AA has certain advantages including direct access and decompression of spinal canal, straight forward graft/cage placement, correction of kyphotic deformity, no paravertebral muscle dissection, no risk of nerve root injury, or cerebrospinal fluid leakage,[2,26,30,31,36] it is a relatively more invasive approach that requires traversing body cavities with unavoidable handling of viscera and great vessels. Such an extensive surgery becomes especially demanding in those who are obese, have comorbidities, and those who have had previous abdominal surgeries.[3,4,17,28,29,35,39-41] It is also associated with late visualization of neural elements and requires two separate incisions for combined anterior–posterior approach, each with additive risks and prolonged hospital stay.[3,4,17,28,29,35,39-41] The most common complications reported with AA are vascular injuries (range 1–16%) followed by thromboembolic events (0–12%).[28,36,42] Other complications causing substantial morbidity include

abdominal hernias and possible impotence or retrograde ejaculation in male patients.[36] Vahldiek and Punjabi[43] and Khodadadyan-Klostermann et al[44] have recommended that anterior column stabilization with cage placement and anterior plating is insufficient to provided required stability following corpectomy in the thoracic and lumbar region. Thus, AA may also require additional PA for achieving 360-degree fusion.[3,30,38,39]

Posterior approach for lumbar interbody fusion was first described by Cloward[45] but it did not become popular due to high complication rates. Later, modifications to include pedicle screw fixation resulted in improved rates of arthrodesis with decreased rates of graft extrusion.[45,46] However, a high failure rate of standalone posterior instrumentation via PA and later need of augmentation by AA in a significant number of patients is an important argument in favor of AA and against PA.[4,30,39,41] PTA combines the advantages of both AA and PA to achieve circumferential arthrodesis from posterior route only, thereby obviating the need for an additional AA and also offers familiarity, less invasiveness, early visualization of neural elements, and decreased morbidity of PA.[3-16] PTA for thoracic corpectomy and interbody cage placement has been a well-described approach and can be performed with little difficulty as thoracic nerve roots can be easily sacrificed.[3,4,12,17,19,27] The real difficulty is in performing this approach in lumbar spine where one cannot sacrifice the roots and available working corridors are thus very narrow. This is the main reason why PTA has not gained popularity among surgeons for lumbar spinal pathologies. However, recently, there has been a growing interest in this approach for managing various pathologies of lumbar region as well,[4-16,27] and one of the major reasons for this has been the availability of various types of interbody cages including nondistractable mesh cages and expandable ones.[44,47] The nondistractable mesh cages are more difficult to be inserted as compared with expandable cages. In the present study, successful mesh cage placement was performed in 15 patients. Preinsertion, slight distraction across corpectomy level helped in insertion of appropriate sized cage in all cases. However, an important encouraging advancement has been the development of expandable titanium cages which are easier to be inserted in compressed state through narrow corridors bounded by lumbar nerve roots and can be expanded once placed in desired position and orientation.[5,11-13] In the present study, 21 patients underwent expandable cage placement. In our study, we found no significant difference in terms of fusion rates, subsidence, or construct failure between the groups of patients undergoing mesh/expandable cage placement.

In the present study, we achieved a kyphosis correction of 17.44 degrees (from 14.23 to–3.21 degrees), which is comparable to what has been described in the literature.[4-17,38,48] Wang et al[13] reported a kyphosis correction from 26 degrees preoperatively to 12.4 degrees postoperatively among 14 patients with lumbar fractures undergoing surgery via PTA.

Sciubba et al[11] successfully used PTA to achieve average kyphosis correction of 15.9 degrees (from 28 to 12.1 degrees at a 16-month follow-up). Recently, Choi et al[15] described PTA for circumferential arthrodesis in 11 patients with traumatic lumbar fractures. They achieved a mean kyphosis correction of 7.7 degrees (9.2–16.9 degrees) after surgery. These results are comparable to those achieved by AA by various authors.[2,17,26,30,31,36,37,48]

In the present study, we observed a loss of deformity correction from–3.21 to 1.45 degrees (loss of 4.66 degrees) during 36-month follow-up. The loss of kyphosis correction has been consistently observed in various studies in the literature. Wang et al[13] also reported a loss of kyphosis correction from 12.4 to 13.3 degrees at 31 months' follow-up after single-stage thoracolumbar corpectomies and placement of expandable cages in 28 patients. Similarly, Choi et al[15] also observed a loss of kyphosis angle from 16.9 to 15.1 degrees over a 12-month follow-up period. Similarly, loss of kyphosis correction has also been observed by authors using AA.[2,36,37]

In our study, neurologic improvement was observed in 13 (65%) patients while none deteriorated after surgery. There was an average improvement in ASIA score from 2.82 to 4.23 over a period of 36 months. Wang et al[13] reported an improvement in ASIA score from 3.7 to 4.5 over 31 months in their study of 28 patients with traumatic fractures operated via PA. Similarly, Sasani and Ozer[5] and Hofstetter et al[27] noted improvement from 4.0 to 4.4 and 3.7 to 4.2 in their respective studies of 14 and 67 patients with a follow-up period of 24 and 14 months, respectively.

The estimated blood loss (EBL) and operative time in the present study were 1,200 mL and 366 minutes, respectively, which are comparable to that reported in the literature.[3,12,14] Danisa et al[17] compared the results of surgery in thoracolumbar burst fractures, operated via anterior, posterior, or combined approaches. They concluded that the PA was associated with a statistically significant decrease in operative time, blood loss, and need of blood transfusion as compared with anterior and combined approaches. On the other hand, no statistically significant difference was seen with respect to the degree of kyphosis correction or improvement in neurologic functions. Similarly, Lu et al[3] while comparing anterior, posterior, and combined approaches concluded that morbidity is lesser and hospital stay shorter in patients undergoing surgery via posterior-only approach. The anterior–posterior approach was associated with longer mean surgical times (729 vs. 450 minutes), increased EBL (3,154 vs. 1,857 mL), and higher complication rates (41 vs. 29%). Similarly, results have been reported by others as well.[7]

The literature as well as the results of the present study clearly demonstrate the feasibility of circumferential arthrodesis via PTA in the lumbar region, as well as results comparable to those achieved with anterior or combined anterior and posterior approaches. In addition, PTA is associated with either similar or lesser complications as compared with anterior or combined approaches. PTA also offers the advantage of a sense of familiarity to neurosurgeons and spine surgeons.

The present study describes corpectomy and circumferential arthrodesis via PTA in patients with TLBFs. Our study demonstrates the feasibility of placing an adequately sized interbody cage using posterior-only approach for anterior column reconstruction and without injuring nerve roots even in the lumbar region. The key is to perform wide dissection,

adequate mobilization of lumbar roots, and distraction across the corpectomy level.

Limitation

The retrospective nature of the study is the limiting factor of our study.

Conclusion

The PTA although technically difficult, can be used for deformity correction and anterior column reconstruction in TLBFs, without sacrificing nerve roots. The sense of familiarity with PA among spine surgeons, lesser approach-related morbidity, shorter operative time, less blood loss, and the results comparable to anterior or combined approaches make single-stage PTA an attractive and viable alternate option for management of TLBFs and adds to the armamentarium of spine surgeons.

Financial Disclosures
None.

Funding
None.

Conflicts of Interest
The authors declare no actual or potential conflict of interest including any financial, personal, or other relationships with other people or organizations within that could inappropriately influence their work.

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