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# Posterior Pediculectomy and Vertebral Trough-Cut Technique for Reduction of Retropulsed Bone Fragments in Thoracolumbar Burst Fractures: A Surgical Technique and Treatment Algorithm Plan

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## Abstract

**Introduction:** This study aims to describe the feasibility and outcomes of the pediculectomy and vertebral trough-cut technique to reduce bony fragments in thoracolumbar burst fractures. This all-posterior retrovertebral fragment reduction technique requires the complete removal of the pedicle, followed by cutting a trough ventral to displaced retrovertebral burst fragments to create space for easy posterior to anterior fragment reduction.

**Methods:** This was a retrospective study of patients with thoracolumbar burst fractures and canal compromise of more than 50% on axial computed tomography (CT). All patients had neurological deficits secondary to spinal fracture. Each patient underwent removal of the pedicle by cutting a trough ventral to the displaced retrovertebral burst fragment to create space for posterior to anterior fracture fragment reduction followed by posterior instrumentation and fusion.

**Results:** Thirteen patientswith a mean age of 33 (24-50) years were analysed. All patients' retropulsed fracture fragments were approached via a pediculectomy. Additional trough cut was performed in 9 patients when the retropulsed fragment was deemed to be irreducible. The average post to pre-operative improvement in axial compromise was 60.7% while the average improvement in vertebral height was 33.9% and the average improvement in vertebral body angle was 9 degrees. All patients experienced mean improvement in ASIA grade of 2. Eleven out of thirteen of the patients were able to walk independently at last follow-up.

**Conclusion:** The pediculectomy and vertebral trough cut technique for the reduction of retropulsed fragments in burst thoracolumbar fractures is feasible and reproducible with good clinical and radiological outcomes..

## Introduction

Traumatic fractures at the thoracolumbar junction (T10–L2) are the most common fractures found in the spinal column [1]. Thoracolumbar burst fractures are the second most common thoracolumbar fracturesafter compression fractures with almost 25,000 cases reported annually in the United States [1]. Burst fractures occur when the vertebral segment is subjected to an axial or flexionload, which leads to a failure of both the anterior and middle column of the spine with retropulsion of the posterior vertebral wall into the spinal canal resulting in neurological injury.

Stable burst fractures with no neurological compromise or disruption of the posterior osseo-ligamentous complexare managed with bracing and early mobilization [2]. Unstable burst fracture with retropulsed bone fragments compromising the spinal canal leading to neurological deficits require surgical decompression, correction of spinal deformities and fracture stabilization [1,3]. Surgical approaches employed to expose the retropulsed spinal fragment include laminectomy, lateral extracavitary techniques, anterior vertebrectomy and posterior vertebral column reconstruction (PVCR) [3-6].

The aim of this study is to describe the feasibility and outcome of the use of pediculectomy and vertebral trough cut technique to reduce bony fragments in thoracolumbar burst fractures. This all posterior retrovertebral fragment reduction technique requires first the complete removal of the pedicle (pediculectomy), then followed by cutting a trough (trough cut) ventral to the displaced retrovertebral burst fragment to create space for easy posterior to anterior fracture fragment reduction. We also propose a treatment algorithm for the treatment of unstable burst fractures with neurological deficits.

## Materials and Methods

This is a retrospective single surgeon study of patients with thoracolumbar burst fractures and spinal canal compromise by retropulsed fracture fragment of more than 50% on axial computed tomography (CT). All patients had neurological deficits secondary to spinal fracture and preoperative and postoperative Asia scores were recorded [7]. Plain radiographs, CT and magnetic resonance imaging (MRI) were used to assess the level of injury and to determine the extent of neural compression. Each patient's fracture was classified according to the AO spine thoracolumbar classification system [8], the Thoraco-Lumbar Injury Classification and Severity score (TLICS) and the Gaines Load Sharing Classification [9,10].

Using pre-operative CT, the percentage of axial canal compromise was determined using the formula $\alpha = (1-x/y) \times 100$. $\alpha$ is the percentage of canal compromise, x is the narrowest mid-sagittal diameter of the spinal canal at the level of injury, and y is the average mid-sagittal diameter of the spinal canal at one level above and below the injured segment [5].The vertebral body angle of the fractured vertebral body was measured as the angle between the upper margin of the vertebral body and the lower margin of the vertebral body [5].The vertebral

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body height percentage was determined using the formula = 2F/(A+B)×100, where F is the height of the fractured vertebral body, A is the height of the upper vertebral body, and B is the height of the lower vertebral body [5] (Figure 1). A post-operative CT was then performed and the above measurements re-measured to document improvement in canal compromise, vertebral body angle and height. All perioperative complications and postoperative neurological compromise was recorded.

**Surgical Technique**

A standard midline posterior approach was performed to expose the fracture site and its adjacent vertebrae for instrumentation. Under loupe magnification a laminectomy and partial facetectomy was performed at the fracture site and the corresponding exiting and transversing nerve roots were identified and protected. The pedicles of the fractured vertebrae were identified. With the use of a high-speed burr a pilot hole was created within the pedicle and then widened until the pedicle walls become thin and removed with a pituitary rounger. The author would prefer to remove the pedicle only at the side where maximum retropulsion of the burst fragment has occurred (Figure 2a).

A Penfield and Macdonald were then used to free the dura posterior to the retropulsed fragments to avoid dural entrapment within the retropulsed fragments. The Macdonald was then used to glide over the retropulsed fragments in the midline to gauge the extent of the displacement. The retropulsed fragment was gently pushed forward with a reversed angle curette to assess its reductability. Care was taken to avoid sudden recoil of the curette when attempting to reduce the fragment into the vertebral body to prevent traumatisation of the spinal cord (Figure 2b). During fracture manipulation, a nerve-root retractor is used to protect the neural elements and a temporary rod was then applied on the contralateral side for fracture stability.

If the retropulsed fragment was not reducible, a trough was then made along the posterior one quarter of the vertebral body on the lateral wall where the pedicle was removed. A 3mm ball tipped high-speed burr (Midas Rex, Medtronic, Minnesota, USA) is used to create this trough cut from lateral to medial at a depth of 0.5cm below the posterior vertebral wall (Figure 2c). This weakens the posterior wall of the vertebrae and creates room to allow the retropulsedfragement in the midline to be easily reduced into the vertebral body (Figure 2d). After instrumentation, and fracture deformity correction, posterolateral fusion was performed (Figure 3).

## Results

13 patients, 11 male and 2 females with a mean age of 33 years (range 24-50) were analyzed. The mechanism of injury was fall from height in 11 patients and motor vehicle accident in two patients. All patients had an AO type A3 burst fracture. The mean preoperative TLIC's score was 7 (6-8) and the mean Gaines score was 5 (4-8). Neurologically4 patients were ASIA A, 2 patients were Asia B, 3 of the patients were ASIA C and 4 of the patients were Asia D. There were 2 patients with preexisting dura tears diagnosed on completion of the laminectomy and these were managed with a Sandwich technique. Firstly, closure with Prolene 5-0 suture following which medical adhesive is applied onto the suture line and dural surface. A gelatin sponge is then trimmed and placed over the tear and its adjacent area

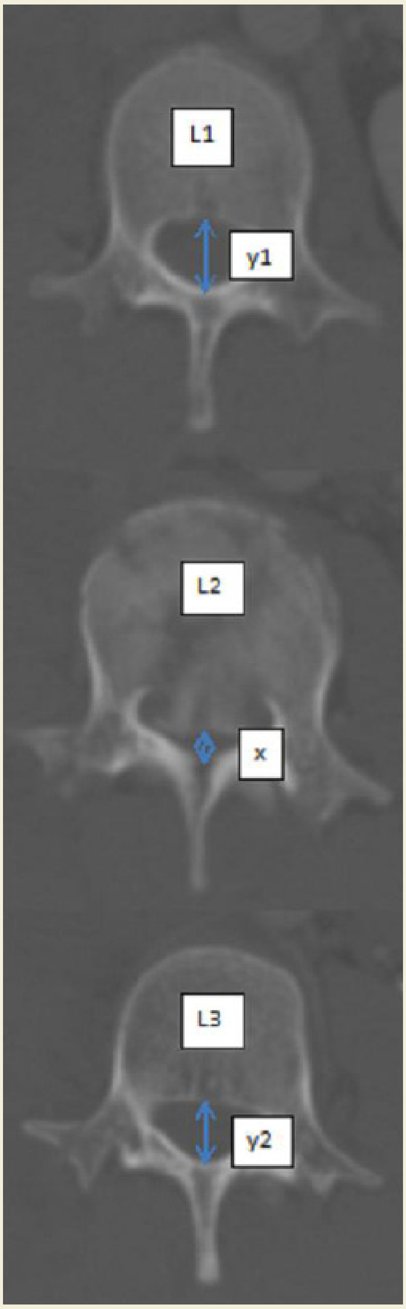


**Figure 1:** Measurement of the percentage of axial canal compromise, vertebral body angle and vertebral body height percentage.

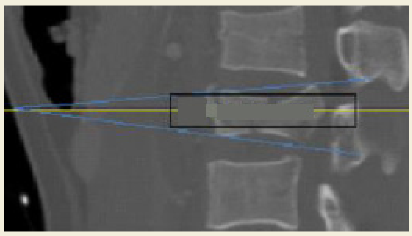

**Figure 1a:** Measurement of the percentage of axial canal compromise is performed by α= (1-x/y) ×100, where y= (y1+y2)/2.

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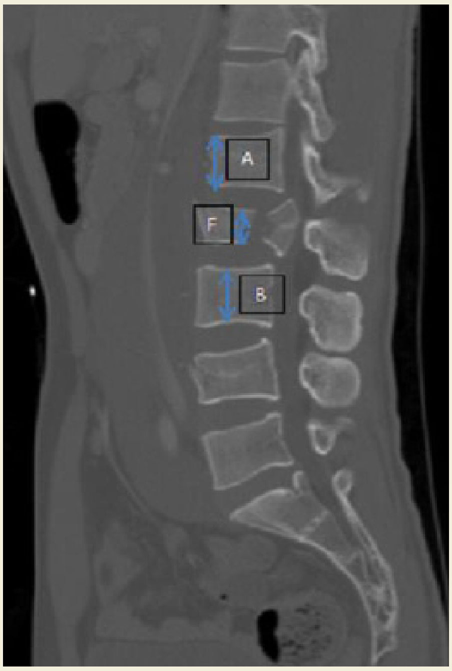


**Figure 1b:** Vertebral body angle measured as the angle between the upper margin of the vertebral body and the lower margin of the vertebral body.

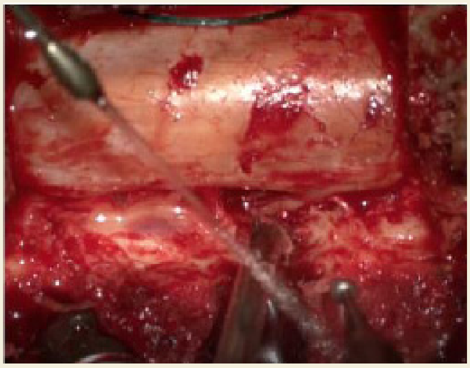

**Figure 2a:** Pilot hole created with high speed burr and widened till pedicle walls are thin enough to be removed with a rounger.

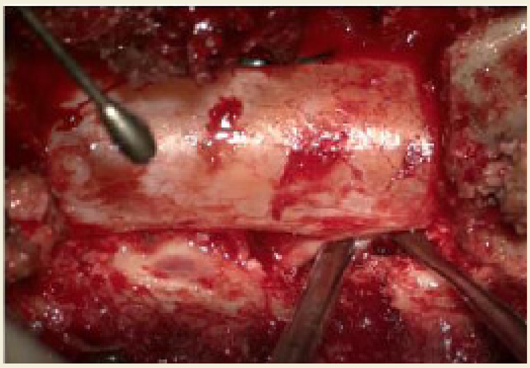

**Figure 2b:** Use of a Penfield retractor to assess extent of retropulsed fragment and assess reducibility.

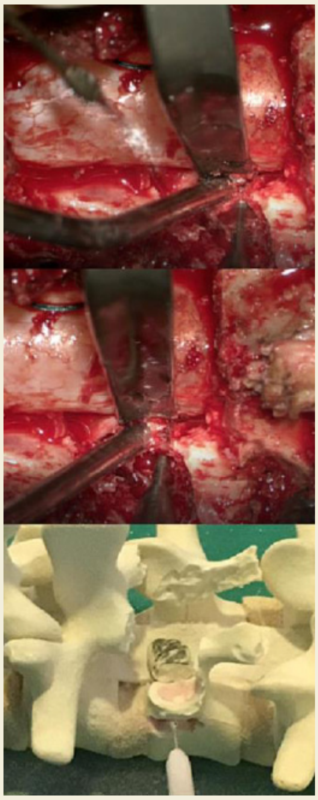

**Figure 2c:** A high speed burr is used to create this trough from lateral to medial to a depth of 1cm below the posterior wall.

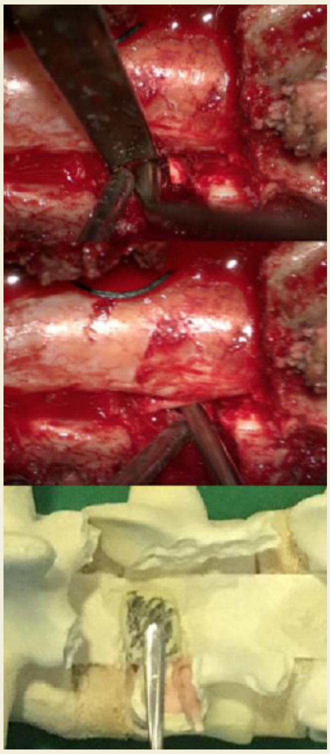

**Figure 2d:** Reduction of retropulsed fragments into trough within vertebral body.

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**Figure 3:** Preoperative images of a 50 year old male with an L1 burst fracture after a fall from height. There was more than 50% vertebral canal compromise with cord signal change and kyphotic deformity. Pre, postoperative and 3 years post-operative CT scan and radiographs demonstrating reduction of retropulsed fragment and decrease in canal compromise as well as correction of kyphotic deformity.

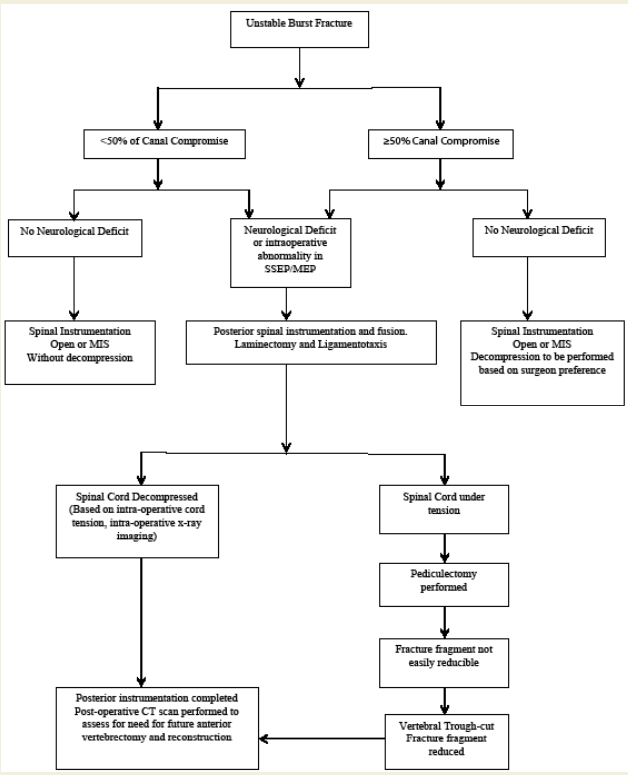


**Table 1:** treatment algorithm for the surgical treatment of thoracolumbar burst fractures via an all posterior approach.

following which a second layer of medical adhesive is sprayed over the gelatin sponge and its edges.

All patients' retropulsed fracture fragments were reduced via a pediculectomy. In this series all pediculectomies performed were unilateral on the side where maximum retropulsion had occurred. Additional trough cut was performed in 9 patients when the retropulsed fragment was deemed to be irreducible. None of the patients required anterior vertebrectomy. Mean operative time was 310 minutes (243-358) and mean blood loss was 795mls (100-2000). Pre-operatively, the mean axial canal compromise percentage was 61% (50-90), the mean vertebrae body height percentage was 59%( 45-80) of the original height. The mean preoperative vertebral body angle was 15 degrees (7-28). All patients had radiological improvements postoperatively with the mean axial canal compromise percentage reduced to 24% (9-39), mean vertebrae body height percentage was restored to 79% (range 65-95) and the mean vertebral body angle was increased to six (2-10) degrees. Percentage improvement in axial compromise and vertebral height was calculated by the following formula (postoperative finding-preoperative finding)/ preoperative finding) x 100%. The average post to pre-operative improvement in percentage of axial compromise was 60.7% while the average improvement in vertebral height was 33.9% and the average improvement in vertebral body angle was 9 degrees. The mean duration of follow up was 18 months (range 3-120 months).

At the time of discharge from hospital, all patients experienced improvements of mean 2 grades (1-4) in Asia score. 11/13 of the patients were able to walk independently at time of last follow-up. The two patients who were unable to walk upon discharge were both polytrauma patients who had had multiple lower limb fractures and were loss to follow up. One patient had a post-operative wound infection and 1 patient had screw malposition requiring screw revision surgery.

## Discussion

The surgical goals of treatment of for thoracolumbar burst fractures with spinal canal compression and neurological deficit is decompression of neural structures, correction of spinal deformity, spinal stabilization and fusion. However, the ideal surgical technique to remove or reduce the retropulsed fracture fragment is still up for debate [11-15]. Surgical decompression and indirect reduction of fracture by ligamentotaxis have been described [12,16,17]. The role of decompression and physical removal of retropulsed fragments is controversial. Miyashita et al showed that in patients with burst fractures treated without decompression [18], spinal canal compromise decreased with time, and all patients with incomplete paraplegia had improved by at least one Frankel grade at the time of final follow up. However, in the same study 50% of their patients remained incompletely paraplegic and had to walk with aids [18]. Fehlings et al showed in the STASCIS study that surgical decompression of the compressed spinal cord within 24 hours of injury was associated with better neurological outcomes [19]. In our hospital, we practice early fracture stabilization and neuro-decompression of patients with burst fractures having neurological deficits. All our patients experienced an improvement in Asia score and 11 out of 13 patients were able to walk at the time of final follow up. Two of our patients were lost to follow up and we were unable to record their final ambulatory status, although both patients had an improvement in their Asia score from Asia A to

Asia B while hospitalized but were unable to ambulate due to lower limb fractures.

Several authors have recommended the use of an anterior approach to allow for better exposure of the fracture vertebrae and direct removal of the retropulsed fragments [6,11,15]. However, this is associated with approach related complications such as intercostal neuralgia, abdominal wall outpouching and pneumothorax [6,11,15]. In recent meta-analysis the anterior surgical approach in the treatment of thoracolumbar burst fractures was associated with longer operative time [20-22], greater blood loss and greater cost when compared to the posterior approach alone. Similarly Tan et al performed another meta-analysis and reported that a combined anterior and posterior approach to thoracolumbar burst fracturesdid not result in additional improvement inclinical, radiological (including kyphotic deformity) and functional outcomes [23], but lead to longer operative times, increased blood loss and prolonged hospital stay when compared to a posterior approach.

Kim et al described the reduction of the retropulsed burst fracture fragments into the vertebral body via a prone posterior approach with laminectomy and minimal facetectomy without the removal of the fractured bone fragments [24]. The mean postoperative spinal canal diameter improvement was 38%of total canal diameter at follow-up. This suggests that repositioning of the retropulsed fragments may be sufficient to reduce spinal cord compression and compromise. Packing of the retropulsed fragments within the vertebral body may contribute to a more compact vertebral body with decreased loss in vertebral height, and make screw insertion and bone fusion more easy. In their series, the mean vertebral body height improved significantly 27% after surgery from 41.3% preoperatively to 68.3% postoperatively. Similarly, in our studythe mean improvement in canal diameter was 60.7% and vertebral height restoration was 33.9%. We propose that the additional improvement in spinal canal restoration was achieved by the addition of pediculectomy with or without the trough cut technique.

Kwon et al have reported their fracture decompression experience by removing the pedicle of the fractured vertebrae via a retroperitoneal anterior approach and achieved an 81.9 % canal restoration (5). Six patients (33.3%) had dysesthesia at the incision site due to intercostal nerve injury. Our technique avoids the complications and operative time associated with removal of the retropulsed fragment by an anterior approach. Kaya et al described a posterior transpedicular approach where they removed the medial and superior wall of both pedicles to visualise the dural sac and the retropulsed fracture fragment followed by reduction of the retropulsed fragment into the fractured verterbrae [4]. They did not report the percentage of reduction in canal compromise. 23 of the 28 patients in their study showed neurological improvement after surgery with 71.4% of patients able to ambulate at 1 year after surgery. In our study all patients experienced improvement in Asia score, (mean 2 grades (1-4)) and 11/13 of the patients were able to walk independently at time of last follow-up. Maciejczak et al and Xiong et al have described approaches involving a partial or complete pedicle removal combined with vertebrectomy [25,26]. However our technique avoids the blood loss and surgical time involved with performing a vertebrectomy.

The concept of pediculectomy with the complete removal of the pedicle at the fractured vertebrae via a posterior approach allows a tangential path to reach the retropulsed fragment without the need for cord manipulation or retraction. This provides a safe surgical corridor for the reduction of bony fragments and avoids iatrogenic injury due to manipulation of fracture fragments. In addition, post pediculectomy, the size and reducibility of the retropulsed fragment can now be assessed easily from the cephalad to caudad direction, as the pedicule no longer blocks visualisation of the retropulsed fragment.

Another novelty of the current reported approach is the vertebral trough cut technique. The concept of the vertebral trough cut is to create a small trough anterior to the retropulsed fracture fragment. This is performed by cutting a trough in the lateral wall of the fractured vertebrae anterior to the retropulsed fragment at the side of the pediculectomy has been performed. This trough cut creates a void anterior to the retropulsed fragment, to make way for reduction of the retropulsed fragments into the fractured vertebral body. This improves our ability to reduce the retropulsed fragment into the fractured vertebral body. The use of pediculectomy and vertebral trough-cut technique provides a wide surgical corridor to reach the contralateral pedicle without the need to remove part of the contralateral pedicle as described by Kaya et al [4]. The reconstitution of the retropulsed fracture fragment into the injured vertebral may lead to better bone healing and vertebral height maintenance and reduce the risk of failure of the posterior vertebral construct. Furthermore, the void created by the trough cut adds safety to preventre-herniation of the reduced spinal fracture fragments into the spinal canal, which was confirmed in our post-operative CT scan results.

One of the limitations of our study was the small number of patients in this series and the need for a comparison group to better evaluate and compare the clinical outcomes. However, the aim of this study is to demonstrate the proof of concept of the new technique and its potential benefits.A treatment algorithm for the surgical treatment of thoracolumbar burst fractures via an all posterior approach using pediculectomy and vertebral trough-cut is described (Table 1).

## Conclusion

In conclusion, the novel pediculectomy and vertebral trough cut technique for the reduction of retropulsed spine fragments in burst fractures is feasible, safe and reproducible. It is able to provide good radiological and clinical outcomes with minimal post-operative complications. Further larger prospective studies are needed to further validate this concept.

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