

Role of Minimal Invasive Spine Surgery Techniques in Thoracolumbar Burst Fractures

Kanwaljeet Garg¹ Deepak Agrawal¹ 

¹Department of Neurosurgery, All India Institute of Medical Sciences, New Delhi, India

Address for correspondence Kanwaljeet Garg, MBBS, MCh, Department of Neurosurgery, All India Institute of Medical Sciences, New Delhi 110029, India (e-mail: Kanwaljeet84@gmail.com).

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Abstract

Keywords

- ▶ burst fracture
- ▶ thoracolumbar
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Thoracolumbar burst fractures are one of the most common traumatic fractures seen. Management options vary from nonoperative to operative. Among the operative approaches, minimal invasive approaches are gaining popularity. However, all the cases are not suitable for minimal invasive approaches. We discuss the various minimal invasive approaches and their role in the management of thoracolumbar burst fractures.

Introduction

Thoracolumbar burst fractures are one of the most common traumatic pathologies seen in any trauma service. A myriad of management options exists for thoracolumbar burst fractures (TLBFs). Management options vary from nonoperative to operative. Bracing and bed rest are used in the nonoperative approach. The disadvantage of this approach is continued pain, residual and possibly progressive kyphosis, and late neurological impairment.¹

Due to these problems, more and more patients prefer an operative intervention in the form of open screw and rod fixation for these pathologies. The purpose of surgery is to decompress the spinal cord, reduce any deformity, and stabilize the spine in normal alignment. The advantage of surgical stabilization over nonoperative intervention includes early mobilization and thereby decreased complications of bed rest. However, not all patients can undergo surgery, for example, patients with comorbidities, and patients with polytrauma, may not be fit for undergoing long surgical procedure.^{2,3} Another option in surgical fixation is by minimal invasive fixation.

Minimal invasive spine surgery (MISS) techniques for spinal fixation were originally described nearly 40 years ago by Magerl and Dick when they first placed a spinal internal fixator in 1977 in nontraumatic cases.⁴ MISS technique is becoming the favored approach recently and several retrospective case series have been published on minimally invasive fixation techniques for spinal trauma, most notably the use of percutaneous pedicle screw fixation without fusion. We shall

discuss an example followed by the role of various MISS techniques in the management of TLBFs in this article.

Example

A 38-year-old male patient, driver by profession, suffered from fall from height. He complained of severe axial back pain. There was tenderness present over the thoracolumbar junction on tapping. Neurological examination revealed no motor deficit but approximately 50% sensory loss in the left L2 dermatome. Imaging revealed a L2 burst fracture. He was advised an external brace. His pain did not get better after using the brace for approximately 2 weeks. He was given an option of percutaneous pedicle screw fixation keeping in view his profession and desire to return to work early. He underwent percutaneous L1 to L3 fixation with a screw in the right L2 pedicle. Postsurgery, he was mobilized, and his pain got better (▶ Fig. 1–7).

Advantages and Disadvantages of Open Fixation

There are many advantages and disadvantages of one technique over the other. One gets clear operative field and exposure to the vertebrae in the open surgical approach. It is easier to decompress the thecal sac and reduce any deformity by open approach. One can achieve fusion with open techniques, which is the ultimate goal in any kind of spinal fixation surgery. However, these approaches are associated with a large amount of blood loss and slow postoperative recovery. Long-term results of open fixation are available and are highly satisfactory.

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Fig. 1 X-ray lateral view showing L2 fracture.



Fig. 2 Computed tomography (CT) scan sagittal image showing L2 burst fracture.

Advantages and Disadvantages of MISS Approach

MISS approach using percutaneous screws is usually associated with lesser operation time and blood loss and at the same time it has the advantages of open approach like restoration of sagittal alignment and stabilizing fractures. There is



Fig. 3 Computed tomography (CT) scan axial section showing a bony fragment protruding into the spinal canal.

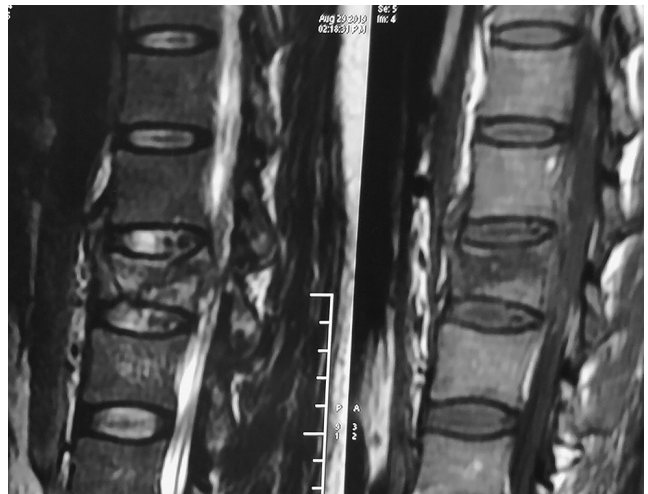


Fig. 4 Magnetic resonance imaging (MRI) sagittal section T2WI and T1WI showing the fracture morphology.



Fig. 5 Postoperative computed tomography (CT) scan sagittal image showing L2 burst fracture and pedicle screws in L1 and L3 in situ.

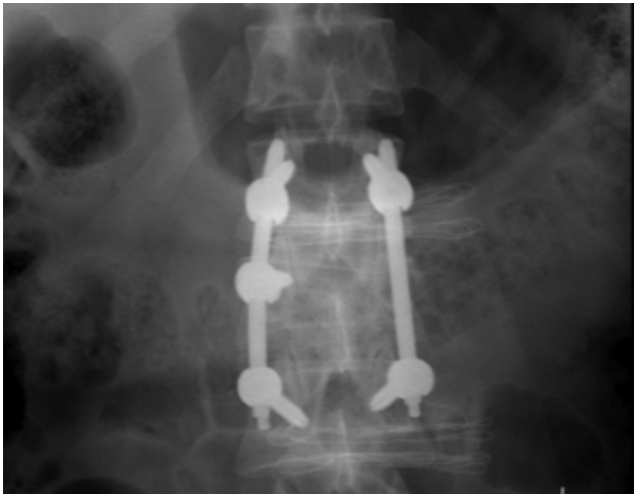


Fig. 6 X-ray anteroposterior (AP) view showing bilateral L1 and L3 screws, and right-sided L2 screw in situ.



Fig. 7 Computed tomography (CT) scan axial section showing pedicle screw in the fracture level on the right side where the pedicle is intact.

less damage to the paraspinal soft tissue and hence postoperative pain is also less. Fusion cannot be attempted in purely percutaneous techniques as bone graft cannot be placed. This remains an important downside of these techniques as there may be implant failure due to loosening of screw–bone interface due to the absence of fusion. However, mini-open approaches allow access for arthrodesis. Other potential drawbacks of this approach include loss of fixation, delayed kyphosis, and nonhealing of the fracture.^{3–5} There is paucity of literature describing the long-term efficacy of percutaneous pedicle screw fixation for traumatic thoracolumbar fractures.

There are many different types of minimally invasive techniques available, which can be used as per the fracture type and need of decompression and/or corpectomy. We will review the technique and results published for each technique.

Percutaneous Pedicle Screw Fixation

Percutaneous pedicle screw fixation is attempted when there is instability and direct decompression is not required. Slight deformity can be corrected by this technique and ligamentotaxis can also be done by distraction. It is the simplest technique and can be done pretty quickly, which is important in patients who are medically not so fit for long duration surgery and cannot tolerate blood loss.

Surgical Technique

After induction, the patient is positioned prone on a spine table or any other radiolucent table as X-rays in anteroposterior (AP) view are required during the surgical procedure. Pedicles are localized in AP view X-rays, and an approximately 1.0 to 2.0 cm skin incision is made over the lateral aspect of the pedicle and the underlying fascia is split. A Jamshidi needle is positioned on the lateral and superior edge of the pedicle (2 O'clock position for the right side and 10 O'clock position for the left-sided pedicles) and is slowly advanced into the pedicle under fluoroscopic guidance without breaching the medial pedicular wall. A lateral X-ray can be done at this stage to check that the needle has gone past the pedicle into the vertebral body. Following that, a guide wire is inserted into the vertebral body through the needle, and the needle is carefully removed. The dilator is placed through the guidewire, and tapping is done for screw insertion. After tapping to the junction of the pedicle and vertebral body, a cannulated percutaneous pedicle screw is placed over the guide wire into the pedicle and vertebral body, and the guide wire is then removed after the screw has entered the vertebral body. Proper positioning of the screw is checked under fluoroscopy. Under fluoroscopic guidance, a longitudinal rod is placed in the percutaneous pedicle screw heads through a small incision made cranially or caudally. Compression can be performed prior to placement of locking nuts. Incisions for screws and rods placement are irrigated and closed. The procedure can also be done under image guidance using PAK needle (Medtronic) using navigation.

Review of Literature

Grossbach et al described a series of 11 patients who underwent posterior percutaneous pedicle screw placement for flexion-distraction injury of the thoracolumbar junction.⁵ They then compared kyphotic angulation, American Spinal Injury Association (ASIA) grade, operative time, and blood loss with a group of 27 patients treated with open fixation and fusion surgery. They found that there were no differences between the open and MISS treatment groups in regard to ASIA grade and kyphotic angulation. They did find significantly lower blood loss in the MISS group and a trend toward shorter operative time in the MISS group (not statistically significant). One patient in each group required hardware revision for misplaced screws. The only clinical outcome measure used by the authors was the ASIA grade; however, all patients who underwent MISS were neurologically intact preoperatively and remained so after surgery. The authors

provided only an average length of follow-up of 11.8 months for the MISS group and did not disclose if any patients were lost to follow-up.

Lee et al studied 59 patients, who underwent either percutaneous ($n = 32$) or open ($n = 27$) short-segment pedicle screw fixation for stabilization of TLBF between December 2003 and October 2009.⁶ They studied the Cobb angle, vertebral wedge angle, and vertebral body compression ratio among the radiologic parameters. Visual analogue scale (VAS), the Frankel grading system, and Low Back Outcome Score (LBOS) were measured for functional assessment. They found that regional kyphosis (Cobb angle) showed significant improvement immediately after surgery in both the groups and it was maintained until the last follow-up, compared with preoperative regional kyphosis. Postoperative correction loss showed no significant difference between the two groups at the final follow-up. In the percutaneous surgery group, there were significant declines of intraoperative blood loss, and operation time compared with the open surgery group. Clinical results showed that the percutaneous surgery group had a lower VAS score and a better LBOS at 3 and 6 months after surgery; however, the outcomes were similar in the last follow-up. They concluded that although both groups showed favorable clinical and radiologic outcomes at the final follow-up, percutaneous pedicle screw fixation without bone graft provided earlier pain relief and functional improvement, compared with open fixation with posterolateral bony fusion.

Similar good results with percutaneous fixation in TLBF has been shown by another study.⁷ One hundred sixty-six patients were included in a recent meta-analysis involving 8 studies.⁸ Average age was 46 years and 27% of patients had polytrauma. Average surgery time was 91 minutes, with an average blood loss of 95 mL. Reported complications were nonhealing fracture in three (2%), infection in one (0.6%), malpositioned screw in one (0.6%), and hematoma in one (0.6%) at a median follow-up time of 26 months. Pain improved by an average of 6 points after surgery according to VAS, and mean kyphosis correction in these studies was 8.5 degrees. The authors concluded that minimally invasive, percutaneous pedicle screw fixation is a viable option for the management of traumatic thoracolumbar fractures in neurologically intact patients especially those who are older and/or present with polytrauma may most benefit from this type of intervention.

Posterior Minimally Invasive Corpectomy

Corpectomy can also be performed via a mini-open posterior transpedicular or posterolateral approach apart from the open anterior or lateral approaches. Chou and Lu reported a series of eight patients, which included majority of patients with metastasis along with one patient with a traumatic L1 burst fracture, who underwent a mini-open transpedicular corpectomy.⁹ A single midline posterior skin incision was made and reflected over the fascia. Percutaneous pedicle screw fixation was done at two levels above and below the level of the fracture using stab incisions through the fascia. An open midline fascial opening at the level of the corpectomy was then made. Expandable tubular retractors were then

used and a complete laminectomy at the index fracture level as well as a partial laminectomy above and below the index level was then done. A transpedicular corpectomy was done as is done in routine open surgeries. The authors compared their small series to a cohort of patients, including one trauma patient, who underwent open surgery. They did not see a significant difference in outcomes or complications. However, the follow-up was quite short in their series and was only 8 months in the patient with traumatic fracture.

Lateral Minimally Invasive Corpectomy

Recently, mini-open lateral approaches are gaining popularity for various etiologies like degenerative diseases. The advantage of these approaches is that they provide direct visualization while minimizing approach-related soft-tissue dissection. Smith et al described their experience of treating 52 patients for traumatic thoracic or lumbar fractures with a mini-open lateral approach for corpectomy.¹⁰ The majority of patients (94.2%) presented with traumatic burst fractures with instability and neurologic deficit. Patients were treated with mini-open lateral corpectomies from T7 to L4, the majority at T12 and L1, and followed for 2 years after surgery. Supplemental internal fixation was used in all patients: 75% anterolateral plating and 46.1% transpedicular fixation (11 [21.2%] patients with combined). Complications included pleural effusion in one patient, intercostal neuralgia in one patient, and dural tears in two patients. No patient required reoperation. Neurologic status improved significantly postoperatively, with 73% of patients either completely neurologically intact or with only slight residual deficits. While 83% of the patients underwent follow-up at 1 year, only half of the patients had 2 years of follow-up.

Anterior Thoracoscopic Treatment of Thoracolumbar Fractures

Kim et al published their experience of treating thoracolumbar spine fractures with a thoracoscopic minimally invasive approach.¹¹ The authors' surgical technique involved a left lateral transpleural approach using multiple portals via a thoracoscopic approach to the fractured vertebra. They then performed a thoracoscopic vertebrectomy and reconstruction with either an expandable cage or a bone graft. Patients with flexion distraction injuries underwent posterior pedicle screw fixation in addition to corpectomy. The authors reported an overall 11% complication rate, which included aortic injury in one patient, conversion to open surgery in three patients, hardware failure in five patients, and neurological deterioration in one patient. However, these thoracoscopic techniques require a significant amount of training, as the endoscopic image is two-dimensional.

Management Algorithm

Dhall et al proposed management algorithm in choosing an appropriate approach for a patient with TLBF.³ They combined decision making with Thoracolumbar Injury Classification and Severity (TLICS) scoring system. There is no confusion regarding the management of patients with a TLICS score of less than 4, and an external brace is recommended.

External brace and surgical fixation are equally good options for patients with a TLICS score of 4. The minimal invasive options for such patients include either corpectomy by minimal invasive approach via anterior or lateral route and instrumented fixation or a posterior percutaneous screw fixation resulting in instrumented fixation and possibly fusion. Since no fusion can be attempted in the latter approach, there is always a concern regarding the increased risk of implant failure. Moreover, long-term follow-up data regarding the rate of fusion following percutaneous fixation is not yet available. It has been seen that the rate of fusion following traumatic fractures are very high in patients with ankylosing spondylitis or diffuse idiopathic skeletal hyperostosis. Hence, these patients can be good candidates for a posterior percutaneous screw-rod fixation and reduction of the fracture, if their TLIC score is more than 3.³

Some authors have suggested to remove the pedicle screws inserted percutaneously after fusion has occurred suggesting an “internal brace” like role of the pedicle screws. Definite advantage of this strategy is not clear though. Moreover, the second surgery has its own risks and morbidity.

It has been claimed that percutaneous fixation is a good option in patients with polytrauma, as mentioned earlier. However, it has to be kept in mind that this is true only for the surgeons who are routinely doing percutaneous fixations and take short time to insert percutaneous screws.

In patients with a TLICS score of more than 4, stand-alone percutaneous posterior fixation is not a good option as without fusion the chances of hardware failure will be very high. It can be used to supplement open or mini-open instrumented fusion via either an anterior/lateral or a posterior approach as described earlier in this article.

Conclusion

Minimal invasive techniques are becoming popular in the management of patients with TLBF. However, one has to be very careful in selecting patients to be managed with minimal invasive techniques. Patients with a TLICS score of 4 can be managed with percutaneous pedicle screw fixation. There is no sound scientific rationale available as of now in taking out the hardware after some time in these patients. Patients with TLICS score of more than 4 always

need arthrodesis and should never undergo percutaneous pedicle screw fixation alone.

Conflicts of Interest

None declared.

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