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A Nerve Sparing Procedure for Posterior Access Thoracolumbar Fracture Surgery

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Abstract

Background: Treatment of thoracolumbar fractures often requires surgery, but there is no consensus as to the preferred method.

The results of a nuanced surgical procedure use a posterior approach and aimed at preserving the integrity of the neural elements.

Methods: The files of 14 patients who underwent surgery for complex thoracolumbar fractures at a single tertiary hospital during a four-year period were reviewed. During a single-stage procedure, performed via a posterior approach, a titanium mesh cage was inserted into the vertebral cavity using a maneuver which protected the nerve roots. Outcome measures included neurological status, sagittal profile of the spine, spinal stability, height restoration and decompression.

Results: Seven patients presented with Type A fractures according to the AO Spine classification, three of them with two simultaneous fractures. One patient suffered from a type B fracture and three patients from type C fractures. While most patients displayed a preserved neurological status, three were paraplegic on admission (Frankel grade A). The suggested procedure has allowed for direct canal decompression and has resulted in immediate stability and optimal height restitution. The spinal profile has also improved.

Conclusion: The nerve sparing procedure offered considerable benefits to the patients. Additionally, the technique may be applied also to fractures above and below the T11-L2 segment, and to patients with Frankel grade A lesions.

Keywords: Thoracolumbar spine; Nerve roots; Mesh cage insertion; Burst fracture; Operative nuance

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Introduction

Injuries to the vertebral column are common, affecting about 160,000 individuals each year in the US. Of these, about 20% occur in the Thoracolumbar (TL) region (T11-L2) of the spine. The most mechanically vulnerable area is around the L1 vertebra, which is a transitional zone between the more rigid and stable thoracic spine and the more mobile lumbar spine [1]. Blunt trauma is the major cause of spinal injury, most commonly inflicted by road traffic accidents, falling from height, violence or sports. The most alarming risk is damage to the spinal cord, as the resulting neurological deficits may be significant and irreversible.

Thoracolumbar injuries vary in type and severity, depending on the mechanism of injury and fracture morphology, the extent of neurological deficit, and the integrity of the posterior ligamentous complex. Over the years, several classification systems have been proposed, including the Denis/McAfee classification, the Thoracolumbar Injury Classification System (TLICS) and the AO Spine Thoracolumbar Classification System [2]. The latter classification recognizes three basic types of fractures: Compression injuries (type A), which include incomplete and complete burst fractures (subtypes A3 and A4, respectively), distraction injuries (type B) and translation injuries (type C).

While non-operative treatment involves bracing and medications, surgery allows for neurological decompression, restoration of alignment and preservation of a sagittal balance [3]. Available techniques for surgery of unstable burst fractures (classes A3 or A4 according to the AO Spine classification) include a posterior approach, particularly for indirect canal decompression

and fusion [2]. This procedure involves fusion of a long spinal segment (three vertebrae above the lesion and two below it), to prevent kyphosis, or fusion of a shorter segment, if the vertebral body is less damaged. An alternative, anterior technique involving conus compression is employed for cases of severe vertebral body comminution, canal compression of at least 70%, or kyphosis larger than 30° [4,5]. There is also a technique that combines anterior and posterior access. This method, which is used to treat unstable burst fractures, provides immediate stability, complete spinal canal decompression, and complete kyphosis correction and maintenance [6,7].

To date, no consensus regarding the most suitable surgical approach and stabilization method for treatment of TL burst fracture with partial neurological damage, has been achieved [8,9]. Here, we introduce a variant, single-stage surgical procedure for complex spinal fractures. The procedure involves posterior access, direct canal decompression, partial vertebral body replacement, anterior column reconstruction, and posterior instrumented arthrodesis using a novel maneuver that protects the nerve roots. Examination of the outcome in 14 patients displays promising results, including neurological improvement in all but one patient.

Materials and Methods

Patients, settings and outcome measures

We reviewed retrospectively the medical files of 14 patients who were treated for complex TL fractures with variable neurological status at a tertiary hospital (Rabin Medical Center, Petah-Tikva, Israel) during a four-year period. All patients underwent surgery using the same procedure. Outcome measures included neurological status, sagittal profile of the spine, spinal stability, full or near-full height restoration and decompression, duration of surgery, as well as incidence of postoperative infection and mortality pending occurrence.

Surgical procedure

The affected spinal segment was exposed through a posterior approach. Pedicle screws were inserted into the vertebrae above and below the fracture in preparation for fixation. Then, laminectomy of the involved vertebrae was performed, as well as excision of the facet joint and adjacent pedicle. This stage was carried out only on one side of the vertebra, i.e., the more compressed or comminuted side, to gain access to the vertebral body. Then, following scraping of all soft tissue from the endplates, a direct, unilateral decompression of the spinal canal was performed, until a partial corpectomy was achieved.

Next, a titanium mesh cage was introduced into the vertebral body cavity. To avoid injuries to the nerve roots during this step, a collapsed cage of a proper size was placed at the corpectomy site perpendicularly to the long axis of the spine. Then, using a 90° long clamp, the cage was inserted into the bone cavity in a rotational movement (Animation 1). Once the cage was positioned inside the corpectomy site, the elongation device was attached to it and the cage was expanded towards the upper and lower endplates.

An Institutional Helsinki Committee approval was secured; however, Patient Consent was not required.

Results

The study included 11 fractures in 14 patients, eight males and six females, with a mean age of 30 (range 16 to 48) years. Seven patients had a type A fracture according to the AO Spine classification (1 - A2.2; 2 - A3; 4 - A4), of whom three patients had two simultaneous fractures (one at A4 + C1 and two at A4 + A2). One patient suffered from a type B fracture (B2.1) and three from type C fractures (C1.3, C3.1 and C3.2) with spinal dislocation. Most of the fractures occurred between T12 and L3. The time interval between injury and surgery varied from 3 h to 20 h, with most patients operated on within 7 h.

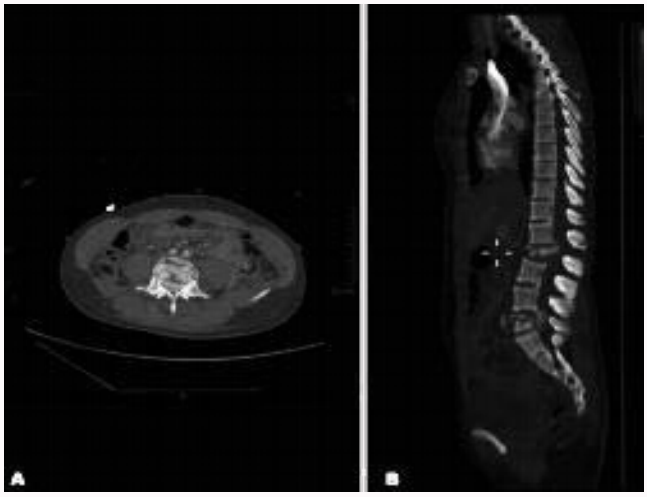

Figure 1: Computed tomography images of the thoracolumbar spine. (A) Sagittal reconstruction showing a fracture in L1, with significant compression of the neural elements. (B) Axial slice shows retropulsion of the bone into the spinal canal at L4 (Duplicated from [18], using CC BY 04 License).

Baseline neurological status, which was recorded for 11 patients, varied among them. Three patients presented with Frankel grade A, of whom two improved to grade D and one to grade E at 30 days from surgery. The remaining patients improved by one Frankel grade, with the exception of one patient who regressed by one grade, but no clear cause for this retrogression was identified.

Both spine surgeons (NO and DS) were impressed by the short duration of the procedure, however, no comparison was made, regarding the timing, with the regular A-P technique.

Sagittal profile, defined as the mean lordosis, improved from preoperative 18° to 32° postoperatively. In all cases, we observed successful decompression and height restoration, as well as immediate stability of the spine. Once their condition permitted, all patients were allowed to walk freely.

Complications included a perioperative infectious disease in one patient, which was treated by irrigation and intravenous antibiotics; removal of instrumentation was not necessary. No death was recorded.

A sample case

A 16-year-old female patient arrived at the emergency room conscious and hemodynamically stable after falling from a height. On admission, both her feet were deformed, which was later diagnosed as bilateral comminuted fractures of ankles and feet, and she could not feel or move her lower extremities. Neurological examination revealed ASIA impairment scale A at the level of T12. No bowel or bladder function was noted. Imaging studies showed severe burst fractures at L1 and L4 levels (Figure 1).

The patient was operated on, 3 h after admission using the above technique. Following partial L1 and L4 vertebral body resection through a posterior approach, a posterior spinal fusion from T11

Figure 2: Postoperative plain radiographs show anteroposterior (A) and lateral view (B) of a thoracolumbar fusion from T11 to S1 (Duplicated from [18], following the CC BY 04 License).

to S1 was performed (Figure 2). After the spine surgery, the patient underwent external fixation of feet and ankles. After recovery in the intensive care unit and a short sojourn in the orthopedic department, she was transferred to the rehabilitation department.

During postoperative recovery, the patient regained partial but ineffective lower extremity movement. Before transfer to rehabilitation, she was assessed as ASIA impairment scale C. Later, the patient slowly regained the ability to stand up and walk with crutches. One year after surgery, she was able to walk with one cane and to control her bowel and bladder functions. The feet regained partial agility. CT images showed optimal decompression of the spinal canal and serial radiographs demonstrated solid and stable arthrodesis of the lumbosacral spine.

Discussion

Spinal fractures are a common injury, often occurring at the TL region (T11-L2). Although there are several surgical techniques for burst fractures of the TL area, none is favored. One of the reasons for this lack of agreement is that the previously proposed classification systems for injury and damage severity have not been proven conclusive [10,11]. Other investigators have proceeded similarly with their TL burst fractures patients [12,13]. However, here, we introduced a one-stage, posterior access surgical procedure that does not require sacrifice of nerve roots [14]. Despite the posterior approach, this method allows for effective and complete removal of bony fragments from the vertebral body and spinal canal.

A special feature of this method is the insertion of the titanium mesh cage into the vertebral body cavity. Usually, the introduction of an expandable titanium mesh cage necessitates the sacrifice of one or two nerve roots [15,16]. Moreover, the loss of nerve roots in the lumbar spine might have devastating neurological consequences. Therefore, to prevent injury to the nerve roots, we first placed the cage perpendicularly to the long axis of the spine, and then inserted it into the bone cavity using a 90° rotational movement. Indeed, the results confirm this maneuver as protecting effectively the nerve roots.

The advantages of the procedure include direct canal decompression, optimal height restoration and immediate spinal stability. Another benefit attained was, that, for all patients, except for one, postoperative neurological improvement was recorded. This includes three patients who progressed from grade A to either grade D (two patients) or grade E (one patient) on the Frankel scale. If confirmed by a future comparison with similar techniques, the present nerve root sparing posterior reconstruction procedure may, in addition, last less than parallel procedures.

Suzuki et al. [17] employed a similar posterior surgical technique for burst fractures of the lumbar spine. However, their procedure involved shortening of the lumbar spine and using a non-expandable cage. This led to subsidence of the cage and to local kyphosis of the affected segment. Nevertheless, their study demonstrated the feasibility of the approach, which can be improved on considerably by adopting the modifications presently described.

It is of note that, although our initial intention was to treat only patients with a burst fracture of the TL spine and with incomplete neurological deficit, we have since included patients with Frankel grade A, with fractures above T11 and below L2, and with C type fractures and spinal dislocation. The subsequent results show that all patients gained a clear advantage from surgery, demonstrating the potential of our proposed variant procedure.

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Video Legend: The posterior access corpectomy with thoracolumbar spine reconstruction, disclosed in the above manuscript, and which highlights nerve roots sparing, is depicted graphically in the following video:

Video URL: https://vimeo.com/244526179

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