Technical Note & Surgical Techniques

Thoracolumbar fractures: Three column stabilization through posterior only approach

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Abstract

Introduction: The combination of anterior and posterior approaches when indicated in unstable thoracolumbar fractures provides the most stable reconstruction. However, the use of both approaches on a trauma patient is associated with significant morbidity. We evaluated the clinical outcome, morbidity and feasibility of single stage posterior midline approach for decompression and three column stabilization using expandable cage and pedicle screws.

Methods: The cases of fifteen patients with severe traumatic thoracolumbar fractures/dislocations that were managed with single-stage decompression, reconstruction and three column stabilization using an expandable cage via an entirely posterior approach were included in this study. Data on age, sex, mechanism of injury neurological status, surgical technique, radiological and clinical outcome were reviewed retrospectively.

Observation: There was no difference between the preoperative and immediate postoperative neurological status of the patients. The average blood loss was 580 ml and average operating time was 4 h 30 minutes. Adequate decompression, fixation and anterior column correction were achieved in all the patients. After a mean follow up period of 21.4 months, no patient complained of local pain and no significant loss of corrections or hardware failure was observed.

Conclusion: Our experience proves that single stage posterior approach using pedicle screws and an expandable cage is a safe and biomechanically reliable method for treating thoracolumbar fractures.

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1. Introduction

Burst thoracolumbar fractures are caused by axial compressive forces and characterized by failure of anterior and middle spinal columns. Transverse and rotational loading may disrupt all the three columns. The majority can be treated successfully without an operation. When deemed necessary, however, numerous surgical techniques have been described, though the best treatment for thoracolumbar fractures is still elusive.

For these unstable neurologically involved fractures, a combination of anterior decompression, reconstruction and posterior instrumentation is often suggested for optimal stability [1]. However, the extensive surgical measures, including the anterior approach increase the morbidity, especially with traumatized thoracic or peritoneal cavities [2,3,4]. Theoretically, stabilization of both columns through a posterior approach would avoid these risks, shortcomings and facilitate rehabilitation.

We have described a transpedicular technique, which was originally designed for severe scoliosis and kyphoscoliosis [5] to perform a column resection by a posterior only approach and applied this for anterior decompression and anterior column reconstruction in patients of thoracolumbar fractures. Additional three column transpedicular fixation was achieved in all the patients. Data on age, sex, mechanism of injury neurological status, surgical technique, radiological and clinical outcome were reviewed retrospectively.

2. Materials and methods

Between September 2012 and October 2013, 15 patients with thoracolumbar injuries were operated in our department.

Neurological deficits were assessed using the American Spinal Injury Association (ASIA) impairment scale (Table 1). Pain was evaluated on a visual analog scale (VAS). Antero-posterior and lateral x-rays of all patients were taken pre and postoperatively and at the last follow-up evaluation. Three-dimensional (3D) computed tomography (CT) or
magnetic resonance imaging (MRI) was performed preoperatively. Rupture of anterior and posterior longitudinal ligament was documented on MRI images.

The percentage of the canal compromise was determined using the formula $x = (1 - a/b) \times 100$, where $x$ is the percentage of canal compromise, $a$ is the narrowest mid-sagittal diameter of the spinal canal at the level of injury, and $b$ is the average mid-sagittal diameter of the spinal canal at one level above and below the injured segment ($b = b_1 + b_2/2$).
canal at the level of injury, and b is the average mid-sagittal diameter of the spinal canal at one level above and below the injured segment (Fig. 1) [6].

Sagittal index was measured to quantify the local kyphotic deformity [7]. It ranges from 10° to 37°. Data on age, sex, mode of injury, neurological status, associated injuries and radiological findings were presented in Tables 2 and 3. Antero-posterior and lateral x-rays were taken of all patients postoperatively and at the last follow-up evaluation. Reconstruction stability was defined by the absence of progressive kyphosis, loss of deformity correction, hardware failure, screw loosening, and local pain related to position changes.

2.1. Operative technique

All procedures were performed under general anesthesia in the prone position. Midline incision given and sub-periosteal exposure of bony elements achieved. The lamina of the fractured vertebrae and the lamina of the cranial vertebrae were removed to expose the pedicles of the fractured vertebrae. Discectomies were performed one level above and one level below of the fractured vertebrae to expose the end plates. The pedicles of the fractured vertebrae were exposed completely. Unilateral or bilateral pedicular resection achieved based over anterior compression. We routinely performed only one side pedicular resection as optimum anterior decompression and cage placement can be achieved unilaterally. Through the resected pedicle, the posterior two thirds of the fractured vertebra were totally removed with a high speed drill and hand curettes. To protect the dura while drilling a thin layer of cortex was left posteriorly which was broken with curved curette later on. Anterior decompression of the dura was achieved. Superior and inferior disc spaces were cleared with curved

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age (y)/sex</th>
<th>ASIA score</th>
<th>Additional traumatic injury</th>
<th>Type of accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21/M</td>
<td>B</td>
<td>Rt calcaneus fracture</td>
<td>Fall from height</td>
</tr>
<tr>
<td>2</td>
<td>46/M</td>
<td>A</td>
<td>Absent</td>
<td>Traffic accident</td>
</tr>
<tr>
<td>3</td>
<td>30/M</td>
<td>A</td>
<td>Rt hemotorax</td>
<td>Traffic accident</td>
</tr>
<tr>
<td>4</td>
<td>56/F</td>
<td>B</td>
<td>B/L calcaneus fracture</td>
<td>Fall from height</td>
</tr>
<tr>
<td>5</td>
<td>17/M</td>
<td>A</td>
<td>Absent</td>
<td>Fall from height</td>
</tr>
<tr>
<td>6</td>
<td>41/M</td>
<td>C</td>
<td>Lt radius fracture</td>
<td>Fall from height</td>
</tr>
<tr>
<td>7</td>
<td>50/F</td>
<td>D</td>
<td>Absent</td>
<td>Fall from height</td>
</tr>
<tr>
<td>8</td>
<td>20/M</td>
<td>C</td>
<td>Absent</td>
<td>Fall from height</td>
</tr>
<tr>
<td>9</td>
<td>47/F</td>
<td>C</td>
<td>Rt hemotorax</td>
<td>Traffic accident</td>
</tr>
<tr>
<td>10</td>
<td>65/F</td>
<td>A</td>
<td>Absent</td>
<td>Fall from height</td>
</tr>
<tr>
<td>11</td>
<td>26/M</td>
<td>C</td>
<td>Fracture cervical spine</td>
<td>Fall from height</td>
</tr>
<tr>
<td>12</td>
<td>33/M</td>
<td>C</td>
<td>Multiple rib fracture</td>
<td>Traffic accident</td>
</tr>
<tr>
<td>13</td>
<td>47/M</td>
<td>A</td>
<td>Absent</td>
<td>Fall from height</td>
</tr>
<tr>
<td>14</td>
<td>56/M</td>
<td>B</td>
<td>Pelvic fracture</td>
<td>Fall from height</td>
</tr>
<tr>
<td>15</td>
<td>66/M</td>
<td>A</td>
<td>Absent</td>
<td>Fall from height</td>
</tr>
</tbody>
</table>

Fig. 2. Operative steps. (A) Trans-pedicular screws put in cranial and caudal vertebrae and rods were placed on one side. (B) Lamina of fractured vertebrae removed and whole pedicle and posterior two third of fractured vertebral body was drilled out, a thin rim of posterior body and posterior longitudinal ligament was left intact until last, which was later fractured with dissector or curved curette (C). Dynamic cage was inserted and expanded till it settles on superior and inferior end plates (D and E). Finally rods were placed on opposite side and compressed (F).
hand curettes and end plates prepared. Anterior part of the fractured vertebrae was kept intact, but a space for putting expandable cage was formed within the fractured vertebrae.

Pedicular screws were introduced into the upper and lower vertebrae and distraction was applied to assist the entrance of the expandable cage. The expandable cage, filled with autologous bone graft, was inserted into the fractured vertebrae through the resected pedicle. The nerve root exiting through the inferior foramen was protected during placement of the cage. Cage was distracted so that it settles optimally on the end plates. The distraction of the cage was guided by preoperative antero-posterior and lateral fluoroscopic image. Finally pedicular screws were loosened and fixed again in compression. The autologous cancellous bone chips were embedded over the decorticated posterolateral gutter to augment fusion (Fig. 2).

Three patients improved neurologically in immediate postoperative period. Mean operative time was three hours and average blood loss was two units. Sagittal correction was achieved in all patients. Paramedian contact of cage was observed in one patient in coronal plane (Fig. 3). Mean follow up period ranges from 20 to 30 months.

3. Discussion

Several treatment options for thoracolumbar injuries are still under debate. Many reports and even multicenter studies have not fully answered the question of how to treat these injuries best. Consequently, up to now, a “gold standard” does not exist [8,9]. Even in case of associated neurologic deficit the choice of treatment seems to be open and we lack a proof for superiority of any surgical treatment [10].

Considering the biomechanical aspect of thoracolumbar anatomy, the vertebral body surface area gradually increases from T5 to L4, indicating that from above downwards more and more weight is borne by the anterior column. On the other hand the lamina index and the mean articular facet area show a gradual increase from T5 to T10 followed by a decrease from T11 to T12, indicating that weight passing through the posterior column gradually increases from T5 to T10 with abrupt change downwards [11].

Because of the inclination of the pedicles towards the bodies and the anterior curvature of the spine in the thoracolumbar junction, there is a tendency for the load to be transmitted from the posterior to the anterior column [11].

The dynamic weight bearing load will change between the two columns under different static and dynamic conditions of the body. At T12 level, the posterior column carries the least proportion of the load passing through the spine at that level while at L5 level about 23% of the total weight is borne by the posterior column alone [11].

In case of thoracolumbar fracture, where anterior column weight bearing mechanism is deficient, the posterior column will undergo severe stress and there will be high chances of implant failure and progressive kyphosis. Addition of a expandable cage to replace the fractured vertebrae significantly decreases the stress over the posterior fixation construct [12,13]. Accordingly, the best management strategy for these fractures is combined antero-posterior approach.
The thoracolumbar spine can be approached anteriorly through thoracoabdominal, transperitoneal or retroperitoneal routes. However, this approach is associated with increased blood loss; pulmonary complications; including pleural effusion and hemotherax. The segmental vessels ligation to mobilize the major vessels may result in spinal cord infarction. The stated incidence of all vascular complications with anterior lumbar spine surgery varies from 5% to 15% [14,15]. Femoral nerve and sympathetic plexus injury may result from retraction of the psoas major muscle. Impotence and sterility, and bowel, urethra, and pancreas injuries have also been reported [15]. Alternatively, long segment fusion with laminectomy was advocated in these fractures, though anterior decompression remains inadequate and posterior laminectomy alone for decompression weakens the posterior column even further [16]. Since our patients were treated through posterior approach, none of these complications occurred and reliable three column stabilization with significant anterior decompression was obtained by this technique in all patients.

Although expandable cage can be used alone, if placed in the intervertebral space, there is a risk of displacement of the vertebra or the device, known as pole-vaulting [17]. Pole-vaulting can be defined as the sliding of the spine caused by effects of the ends leaning on the corpus, resulting in displacement of the graft and vertebra over time. Accordingly, the best method is stabilization of the expandable cage through anterior and, even better, posterior constructs This procedure was achieved in our patients through transpedicular screws.

The another advantage of this approach to anterior approach was preservation of anterior longitudinal ligament (ALL) and anterior part of fractured vertebrae which not only prevents the pole vaulting but also the anterior displacement and rotational strain over the expandable cage. It also prevents trauma to anterior vascular structures during cage placement.

This approach can be performed in a single setting without any need to change the position of the patient. Second correction of the kyphosis angulation can be significantly corrected by compression of the pedicle screw system. Third, repair of dural tears which occurs in 32% of burst fractures can be achieved at the same time [18].

Last but important aspect is every neurosurgeon familiar with spinal operations can perform this surgery without assistance of a thoracic surgeon.

In conclusion, a single stage posterior based partial transpedicular vertebral body resection in combination with circumferential reconstruction using expandable cage and transpedicular screws is a viable technique to safely manage thoracolumbar burst fractures while potentially reducing operation time, risks, and operative morbidity.

References