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Additional vertebral augmentation with posterior instrumentation for unstable thoracolumbar burst fractures

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ABSTRACT

Background: To investigate the role of vertebral augmentation in kyphosis reduction, vertebral fracture union, and correction loss after surgical management of thoracolumbar burst fracture.
Design: Retrospective chart and radiographic review.
Setting: Level 1 trauma center.
Methods: The analysis included patients treated between April 2007 and June 2015, who received pedicle-screw-rod distraction and reduction within two days following acute traumatic thoracolumbar burst fracture with a load sharing score >6. Medical records were retrospectively reviewed for data regarding operative details, imaging and laboratory findings, neurological function, and functional outcomes.
Intervention: Not applicable.
Main outcome measures: Sagittal index, pain score, loss of correction, and implant failure rate.
Results: Nineteen patients were enrolled in this study (mean age, 37.2 ± 13 years; age range, 17–62 years; female/male ratio: 10/9). Of the five patients who received only reduction (no augmentation), one underwent revision surgery because of implant failure and pedicle screw backing out. Compared to patients who received only reduction, those who received both reduction and augmentation showed better sagittal alignment after the operation, with better sagittal index immediately postoperatively and during the follow-up ($p < 0.05$).
Conclusions: Transpedicular vertebral augmentation with calcium sulfate/phosphate-based bone cement may reinforce thoracolumbar burst fracture stability, partially restore vertebral body height, and reduce pedicle screw bending and movement, thereby preventing early implant failure and late loss of correction, especially in patients with excellent fracture reduction.
Level of evidence: Therapeutic level III, retrospective chart review

Introduction

Approximately 90% of spine fractures involve the thoracolumbar spine, and 52% of thoracolumbar fractures occur in the thoracolumbar junction (T10-L2) [1,2], which represents a curved transition zone where the more rigid thoracic component becomes the highly mobile lumbar component [3]. Burst fractures account for 10%–20% of thoracolumbar fractures [4] and can cause devastating injuries with or without neurologic deficit. When managing thoracolumbar burst fractures, the surgical goals include correction of kyphotic deformity, maintaining initial stability and alignment, direct or indirect decompression of neural elements, minimizing the requirements for external immobilization, and promoting early ambulation and rehabilitation [5,6]. Nevertheless, the surgical management of thoracolumbar burst fracture remains challenging and controversial.

There are three major surgical approaches for the management of traumatic unstable thoracolumbar burst fracture [7–10]. The anterior approach typically provides direct decompression with good interbody fusion and better kyphosis correction with anterior

Abbreviations: MRI, magnetic resonance imaging; SI, sagittal index; PCA, postoperative corrected angle; FCA, follow-up corrected angle; VAS, visual analogue scale; ASIA, American Spinal Injury Association.

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column support [11]. However, the operative risk is relatively high, with concerns regarding neurovascular injury and increased blood loss in patients with acute fracture, as well as post-operative complications including intercostal muscle atrophy, pneumothorax, pneumonia, pleural effusion, chylothorax, and prolonged hospital stay associated with retropleural and transthoracic transpleural approaches [12,13]. The posterior approach with instrumentation is more popular among surgeons and provides benefits related to fracture reduction, deformity realignment, lower risk of visceral or vascular injury, decompression of nerve roots entrapped in the dorsal bony elements, and epidural hematoma evacuation [14]. Instrument failure and recurrence of kyphosis are major complications associated with posterior instrumentation, especially when vertebral body reconstruction is not performed [15–17]. The combination of anterior and posterior approaches may be a better choice for long-term kyphosis correction with short fusion segments, but the operative time is longer and surgical trauma is more extensive.

The aim of the present study was to investigate the potential benefits of vertebral augmentation in terms of kyphosis reduction, vertebral fracture union, and loss of correction after surgical management in patients with traumatic unstable thoracolumbar burst fractures.

Methods

Patients and study design

This study involved the retrospective analysis of the medical records of patients who underwent spine surgery between April 2007 and June 2015 at the orthopedic surgery department of the largest medical center in Taiwan. The following inclusion criteria were applied: acute traumatic thoracolumbar burst fracture with load-sharing score >6 [15]; surgery performed within two days following trauma; and fracture treated with pedicle-screw-rod distraction and reduction. All patients were followed-up for at least 12 months after surgery. Medical records were reviewed for obtaining operative details, imaging and laboratory findings, and data regarding neurological function and functional outcomes. Surgical indications included unstable thoracolumbar burst fracture (equal or more severe than AO type, A3) with intractable back pain, progressive neurologic deficits, and cauda equina syndrome. Patient exclusion criteria included pathologic fractures, old fractures with good union or nonunion, and complications from previous spine surgery, determined based on preoperative radiographs and magnetic resonance imaging (MRI) scans.

Radiographic parameters

Imaging investigations included preoperative computed tomography of the thoracolumbar spine for diagnosis, and plain radiography of the thoracolumbar spine before surgery, immediately after surgery, and postoperatively at 3 months, one year, and annually thereafter as part of the long-term follow-up. The sagittal index (SI) was measured on the thoracolumbar plain lateral radiography as described by Farcy et al. [18]. Local kyphosis was measured, according to the Cobb method, between the superior endplate of the upper non-injured vertebra and the inferior endplate of the lower non-injured vertebra. The postoperative corrected angle (PCA) was defined as the difference between the values of SI before and after surgery, while the follow-up corrected angle (FCA) was calculated by subtracting the preoperative value of SI from the SI value at the last follow-up (at least one year postoperatively). Correction loss was defined as the difference in angle between follow-up SI and postoperative SI. Cobb angle measurements for all patients were performed in our hospital by the same spine surgeon.

Surgical techniques

Once under general anesthesia, the patient was placed on a four-post spinal frame in the prone position. The fractured vertebra was identified using a portable radiography device (C-arm) prior to the start of the surgery. The first operative stage consisted of posterior instrumentation performed by inserting monoaxial pedicle screws into the vertebral bodies at one or two levels above and below the fractured vertebra, according to the stability and quality of the bone tissue. Over-bent lordotic rods were forced between the heads of the pedicle screws and caps were applied without locking. Distracting the monoaxial pedicle screws above and below the fractured vertebra achieved fracture reduction with indirect ligamentotaxis. Good reduction was confirmed in the form of a radiolucent cavity in the fractured vertebra obvious under portable radiography (C-arm). Subsequently, the caps on the monoaxial pedicle screws were locked to maintain the reduction. Some patients received transpedicle vertebral augmentation with a bone graft substitute (PRO-DENSE; Wright Medical Technology, Arlington, TN), performed under portable (C-arm) radiographic guidance. Finally, the skin was closed layer by layer, with or without drainage.

Variables of interest and data collection

The main outcome measures were: SI and loss of correction, assessed based on preoperative, postoperative, and follow-up radiographs; pain score on the Visual Analogue Scale (VAS), assessed preoperatively and postoperatively; and implant failure rate, assessed based on follow-up radiographs. Receiving vertebral augmentation was considered the exposure variable, and was determined based on the operative records. Other variables recorded were: age, sex, AO fracture type [19], and neurological function according to the American Spinal Injury Association (ASIA) classification, determined based on the medical charts at admission.

Statistical analysis

Quantitative variables were expressed as mean ± standard deviation and range. The study sample was divided into two groups based on the exposure: the reduction-only group included patients who did not receive vertebral augmentation, whereas the reduction/augmentation group included patients who received vertebral augmentation. The differences between groups were assessed using Mann–Whitney *U* test for continuous variables and Fisher's exact test for categorical variables. The threshold for statistical significance was set at $p < 0.05$. All statistical calculations were performed using SPSS 12.0 software (SPSS, Chicago, IL)

Results

During the period between April 2007 and June 2015, a total of 105 patients underwent surgical management of traumatic thoracolumbar spine fracture. Eight patients in which were treated with anterior reconstruction plus posterior instrumentation and the rest of 97 patients received posterior instrumentation and reduction. In those 97 patients, 78 patients with load-sharing score less than or equal to 6 received only postural reduction, and the other 19 patients with load-sharing score more than 6 accepted pedicle-screw-rod distraction and reduction (the surgical techniques described above), which enrolled in this study (mean age,

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