REVIEW ARTICLE

Principles of Management of Thoracolumbar Fractures

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There is little consensus on treatment of thoracolumbar fractures, which are one of the most controversial areas in spine surgery. The great variations in clinical decision making may come from differences in evaluation of spine stability with these fractures. Few high-quality studies concerning optimal treatment of thoracolumbar fractures have been conducted. This article reviews the conflicting results and recommendations for management of thoracolumbar fractures of currently published reports. Specifically, it addresses issues regarding evaluation of stability, indications for operative treatment, timing of surgery, surgical approach, and fusion length.

Key words: Spinal fractures; Thoracolumbar spine; Treatment outcome

Introduction

Thoracolumbar fractures are usually the result of high energy injuries. Because it is the anatomical and mechanical transition zone between the relatively rigid thoracic and more flexible lumbar spine, the thoracolumbar junction is the most common site of spinal injuries. A highly significant incidence of neurological deficits has been reported in patients with thoracolumbar fractures[1]. Moreover, the late consequences of delayed neurologic deficit and painful kyphotic deformity may significantly impair health-related quality of life[2–4].

One of the most controversial areas in spine surgery, treatment of thoracolumbar fractures presents challenges and problems requiring further study. When making therapeutic decisions for patients with thoracolumbar spine fractures, different spine surgeons may take different factors into consideration. Great variations in decision making about thoracolumbar spine injuries are bound to exert an impact upon the outcomes and prognosis of these fractures that cannot be ignored.

Some large, multi-center studies of thoracolumbar fractures have been conducted[5,6]. However, no universal agreement on optimal management has been reached, in part due to design defects in these studies, in which management options were decided according to the philosophy and personal beliefs of the treating physicians, although the primary results were reviewed from a prospective database. Obviously, studies of limited quality do not provide good scientific evidence for guiding clinical practice.

This article reviews conflicting results and recommendations for management principles of thoracolumbar fractures from currently published reports. Specifically, it addresses issues regarding evaluation of stability, indications for operative treatment, timing of surgery, surgical approach, and fusion length. We hope this information will help physicians to a better understanding of treatment strategies for thoracolumbar fractures.

Evaluation of Stability

It is sometimes difficult to determine whether a fracture is stable or unstable. However, this distinction is important when making treatment decisions, especially when deciding whether to use a nonsurgical or surgical approach for a patient with a fracture. Stability or instability of fractures is primarily a biomechanical concept. However, results and conclusions from biomechanical studies cannot always be translated into accurately interpreting fracture morphology as shown by imaging techniques. Until now, various classification systems have been developed that more or less incorporate the concept of stability.

Denis[7] proposed a three-column model of thoracolumbar spine stability in which unstable fracture was defined as

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disruption of two of the three columns of the spine (anterior, middle, and posterior columns) with emphasis on the importance of the middle column. His theory was supported by subsequent findings of a biomechanical study[8]. Based on the three-column concept, thoracolumbar fractures can be classified into compression fractures, burst fractures, flexion-distraction injuries, and fracture-dislocations. This classification system has frequently been used in clinical practice. However, it does not assist clinicians to base their treatment choices for special patterns of fractures on quantitative assessment of post-fracture spinal stability.

Continuing on the tradition of AO classification of lone bone fractures, the AO classification system for thoracolumbar fractures divided fractures into three groups: Type A (compression), Type B (distraction), and Type C (rotation). Each fracture type can be further classified into groups and subgroups[9]. Because this comprehensive classification system does correlate fracture instability with incidence of neurologic deficit, it may have prognostic value. However, this hierarchical system with more than 50 categories of subgroups does not have sufficient inter- and intra-observer reliability[10,11]. Recently, the preliminary results of developing a new classification system and of assessing the reliability of this system have been reported[12].

A Load Sharing Classification based on severity of vertebral body comminution has been proposed. It grades three separate characteristics of fractured vertebral bodies: vertebral body comminution, fracture fragment apposition, and kyphotic deformity, assigning three severity grades to each[13]. This system was initially introduced to prevent recurrent kyphotic deformity and failure of posterior short-segment fixation with pedicle screws by facilitating an optimal choice concerning the surgical approach. Biomechanical study has shown that the Load Sharing score correlates with the severity of spinal instability[14]. In addition, excellent inter- and intra-observer reliability has been noted, even for inexperienced surgeons[15].

Taken together, stability of thoracolumbar fractures can be roughly evaluated, depending on the fracture type. The fracture types are as follows:

(I) Compression fractures: Resulting from axial loading on a flexed spine, compression fractures are stable because the middle column is intact, an exception being when the anterior column has been greatly compressed with disruption of the posterior ligamentous complex.

(II) Burst fractures: Accounting for the majority of thoracolumbar injuries, burst fractures involve both the anterior and middle columns and are caused by an axial loading. These fractures are characterized by loss of height of the anterior column and disruption of the posterior wall of the vertebral body. Retropulsed bony fragments from the vertebral body often lead to compromise of the spinal canal and subsequent injury to the neural contents. Compared with compression fractures, burst fractures are relatively unstable. According to the classification proposed by Denis, burst fractures are unstable[7]. However, some authors believe that some burst fractures can be regarded as stable fractures[16]. In the AO classification, burst fractures may be coded as A3 or C fractures, which indicates a great variance in the degree of fracture stability. Patients with burst fractures frequently experience correction loss and implant failure after posterior reduction and short-segment pedicle instrumentation[3,17].

(III) Flexion-distraction injuries: Flexion-distraction injuries are usually caused by an anterior shearing mechanism with the rotation axis at, or anterior to, the anterior column, and are characteristically posterior and middle column injuries, or three-column injuries. These injuries are often seen in traffic accident where a seat belt has been used, and may occur through soft tissue and/or bone. Flexion-distraction injuries are defined as Type B lesions in the AO classification.

(IV) Fracture-dislocations: Fracture-dislocations are highly unstable injuries involving all three columns.

Indications for Operative Treatment

The treatment of thoracolumbar fractures aims at restoration of the anatomical integrity and structural stability of the injured spine, thus providing a biologically and biomechanically ideal environment for facilitating functional recovery. Thoracolumbar fractures used to be treated conservatively. Huge advances in spine biomechanics, imaging facilities, and instrumented techniques have led to a shift in management strategy from conservative therapy to surgical intervention over recent decades. However, neurological deterioration is rarely noted in patients treated conservatively for thoracolumbar fractures. From the viewpoint of evidence-based medicine, there is a paucity of high-quality comparative studies on the outcomes of conservative versus operative treatment. Published studies have not supported the conctention that surgical intervention is associated with better outcomes in terms of pain relief and neurological recovery[18–21].

Mechanical instability is usually the first factor favoring surgical management. Surgery is rarely indicated for compression fractures, whereas the majority of flexion-distraction injuries or fracture-dislocations need surgical stabilization. Because surgery is often recommended for thoracolumbar burst fractures with neurological involvement, the main focus of debate is the treatment of thoracolumbar burst fractures without neurological deficits.

In a prospective, randomized study of thoracolumbar burst fractures, Wood *et al*. found that operative treatment did not achieve better results than nonoperative treatment in neurologically intact patients[22]. In contrast, Siebenga *et al*. reported that that thoracolumbar burst (AO Type A3) fractures without neurologic deficit managed by short-segment posterior stabilization had better radiographic outcomes than nonsurgically treated fractures; however, the functional outcome was the same[23]. These studies are limited by small numbers or heterogeneous fracture characteristics of the patients enrolled.

One of the factors supporting conservative treatment of thoracolumbar burst fractures is that spontaneous remodeling of the spinal canal[24] and partial or total resorption of retropulsed bone fragments will lead to decompression of neural contents, regardless of whether the bone fragments have been completely reduced. The underlying mechanisms of spinal canal remodeling remain unclear. In my opinion, nonoperative treatment may be warranted for thoracolumbar burst fractures with canal encroachment without significant neurologic deficit. However, the choice of nonoperative management may mean giving up on efforts to decompress the neural contents. It should be noted that there is no evidence that there is a correlation between decompression and long-term results for patients with significant neurologic involvement.

When making surgical decisions, most spine surgeons do not give primary consideration to the presence and severity of neurologic involvement unless the patient has progressive neurological deterioration combined with spinal canal compromise. Meanwhile, few spine injury classification systems have included the characteristics of spinal cord injury. Denis classified unstable thoracolumbar fractures into three degrees of instability: mechanical instability, neurological instability, and mechanical and neurological instability[7]. Among these, the most severe degrees of instability occur with fracture-dislocations and severe burst fractures with neurological deficit. Recently, some new classification systems integrating results of neurological measures have been developed[25,26]. However, whether these systems are valid for guiding clinical decision making is yet to be confirmed.

Timing of Surgical Intervention

The timing of surgical decompression and stabilization has been controversial[27]. For patients with multiple injuries, resuscitation and life-saving surgery is the first priority, whereas delay in fracture fixation has been recommended. During recent decades, aggressive management of long-bone fractures has been shown to have a positive effect in patient with multiple injuries. Early definitive fixation of unstable fractures of the long bones may decrease patient mortality, days of critical care and mechanical ventilation, and incidence of fracture-related complications, thus decreasing hospital stay and costs. However, new evidence has emerged to suggest that urgent fracture fixation does not always achieve better results and prognosis. In contrast, few studies of the optimal timing of thoracolumbar fracture fixation in multiply injured patients have been undertaken.

In a retrospective study of 147 patients with acute thoracolumbar fractures and multiple trauma, we found that surgical treatment decreases the incidence of pulmonary complications and length of hospital stay[28]. Such findings suggest that surgery allows early mobilization and thereby decreases the complications related to prolonged bed rest. Also, although the surgically treated patients had significantly less pain than the nonoperative ones, no significant differences were found between the nonoperative and operative groups in terms of recovery of neurologic function. The explanation may be that kyphotic correction surgery decreases pain following post-traumatic kyphosis. However, we demonstrated no significant correlation between timing of surgical intervention and incidence of complications. Neither injury severity nor surgical timing had any significant impact on the rate of recovery of neurological function.

With regard to the timing of surgical intervention, the absolute indication for urgent surgery is progressive neurological deterioration in the presence of significant spinal canal compromise. In addition, surgical stabilization is indicated as early as possible for patients with fracture-dislocations and incomplete neurological deficits. Although early fixation of unstable spines may reduce mortality and morbidity of patients, immediate surgery is not mandatory. For poorly resuscitated and hemodynamically unstable patients, we recommend delay in surgical stabilization of thoracolumbar fractures rather than adherence to a rigid protocol. The first priority should be given to life-threatening injuries such as unstable pelvic fractures, and brain, thoracic or abdominal injuries.

Surgical Approaches and Fusion Length

Advances in spine instrumentation techniques have greatly promoted the surgical treatment of thoracolumbar fractures. Posterior instrumentation with pedicle screws has become popular because it has advantages over other posterior fixation systems. Short-segment fixation allows sufficient stabilization, which results in adjacent levels being less affected[29]. However, the indirect reduction provided by posterior implants relies largely on the integrity of the posterior longitudinal ligament, and possibly the annulus fibrosus of the intervertebral disc and anterior longitudinal ligament. Where the posterior longitudinal ligament has been completely ruptured, posterior reduction is often contraindicated. Anterior approaches are particularly advantageous for thoracolumbar spine fractures with severe anterior and middle column or all three-column injuries because they avoid the progressive vertebral collapse and kyphosis that can follow posterior-only surgery. Although it is more invasive and technically demanding, the anterior procedure is more effective because it permits direct exposure and decompression of the neural contents and provides strong load-bearing support to the spine[30].

In contrast to the considerable controversy regarding indications for surgery, current published reports are relatively unanimous that anterior decompression with instrumented grafting is critical to clinical success in patients with significantly unstable thoracolumbar spine fractures, especially those with severe vertebral body comminution, kyphotic deformity, and spinal canal compromise. The Load Sharing Classification has been effectively used for choosing the surgical approach. The posterior approach is indicated for patients with a Load Sharing score of no more than 6 points, whereas the anterior approach should be considered for patients scoring more than 6 points. Following these guidelines successfully prevents recurrence of kyphotic deformity and failure of spinal instrumentation following surgical reduction and fixation[29–31].

The surgical approach of choice depends largely on the surgeons' familiarity with the surgical technique required. If anterior surgery is not feasible due to the systemic condition of the patient or inadequate technical facilities, extending posterior instrumentation and fusion length may be the alternative option. Based on the 3-point fixation principle, long-segment instrumented fusion that includes two or more levels above and below the injured segment can preserve and restore coronal and sagittal stability, prevent recurrent kyphosis, promote fusion and post-reduction stability, and decrease the incidence of implant failure. Long segment fixation and fusion is indicated for fracture-dislocations with severe displacement, especially for those with complete spinal cord injury, or multiple compression or burst fractures. Long-segment fusion sacrifices motion of the fused spine and should not be extended to below L3; also, it is not indicated for fractures with severe comminution of the vertebral body. For manual workers, long segment fixation and fusion should also be avoided so that the motion of the spinal segment is preserved as much as possible.

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