A review of the management of thoracolumbar burst fractures

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Abstract

Background: Burst fractures account for more than half of all thoracolumbar fractures, which often cause a neurologic deficit and present a significant economic burden to the family and society. Accepted methods of treatment of thoracolumbar burst fractures include conservative therapy, posterior reduction and instrumentation, and anterior decompression and instrumentation. However, the management of thoracolumbar burst fractures has been the subject of much controversy.

Methods: Publications reporting clinical data relating to the thoracolumbar burst fractures were reviewed. These articles were determined via review of the results of PubMed searches and articles gathered through compilation of references from those articles.

Results: There exist different criteria for the choice of the management based on the severity of kyphotic deformity, canal compromise, vertebral height loss, and neurologic status. To our knowledge, none of the existing criteria for the treatment of thoracolumbar burst fractures are generally accepted.

Conclusions: In thoracolumbar burst fractures without a neurologic deficit, there is no superiority of conservative therapy over operative therapy. When the neurologic involvement is significant, the choice of operative management is advised. Also, there is no obvious superiority of one approach over the other.

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Keywords: Thoracolumbar spine; Burst fractures; Treatment

1. Introduction

The term “burst fracture” was first defined by Holdsworth [51] as a fracture caused by axial load leading to herniation of the nucleus pulposus of the vertebral disk through the upper end plate, resulting in the disruption of the vertebra from within. In 1983, Denis [32] redefined the burst fracture in his 3-column theory as a compression fracture of the anterior and middle vertebral columns, which causes retropulsion of a posterior vertebral body fragment into the spinal canal, the radiographic hallmark of the burst fracture [24,25,76,78,103]. Nearly 90% of all spinal fractures occur in the thoracolumbar region, and burst fractures compose approximately 10% to 20% of such injuries [32,39,58,79]. Although it is such a common fracture, there are various therapeutic options regarding the ideal management. The advantages of surgery include better correction of kyphotic deformity, greater initial stability, an opportunity to perform direct or indirect decompression of neural elements, decreased requirements for external immobilization, and an earlier return to work [3,23,35]. However, conservative management of thoracolumbar burst fractures in neurologically intact patients with bracing or casting would avoid a surgical intervention with its attendant morbidity. Therefore, it is controversial whether surgical or conservative treatment is more effective in the treatment of thoracolumbar burst fractures, especially in fractures without neurologic deficit. Also, the question as to how these fractures should be approached and stabilized (anteriorly, posteriorly, or combined anteroposteriorly), has been the subject of debate for a long time.

Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging; PMMA, polymethylmethacrylate; SI, sagittal index; TLSO, thoracolumbosacral orthosis; TSRH, Texas Scottish Rite Hospital; VSP, variable screw placement.

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2. Concept of stability

Various studies in the literature have dealt with the issue of radiologic analysis of stability in burst fractures. However, the concept of stability, which is the most important determinant for the choice of treatment method, is still debated. Holdsworth [51] considered the burst fractures to be stable because the anterior and middle columns may be squashed down, whereas the posterior usually remains mechanically intact. Radiographic examination does show an obligatory laminar crack at the site of the burst fracture, but the important surrounding ligaments and muscles remain whole, thus conferring stability on the posterior column [12]. However, Denis [31] concluded that all thoracolumbar burst fractures would be unstable. He stated that the involvement of the middle column was a sufficient determinant for instability without any relation to type or that neurologic instability (third degree). Cantor et al [15] stated that fractures without neurologic deficit, with kyphosis less than 30° and anterior height loss less than 60% were accepted as stable. Cantor et al [15] stated that fractures without neurologic deficit, with kyphosis less than 30° and height loss less than 50%, were defined as stable.

As described previously, although many radiologic parameters such as local kyphotic angle, anterior vertebral height, posterior vertebral height, and canal compromise were defined to evaluate the stability, it is difficult to define the critical values of these parameters that may be required for determining the stability of a burst fracture [12,60,86]. Neurologic status of patients seems to be another important determinative factor for stability for these fractures [80,92,102]. Therefore, the “3-column theory” described by Denis [32] may be the most widely accepted concept in use today. Denis described instability as mechanical instability (first degree), neurologic instability (second degree), and combined mechanical and neurologic instability (third degree).

Recently, MRI has brought out a new dimension in the stability concept and leads us to consider the importance of the posterior ligamentous complex. It is advocated that the evaluation of the posterior ligamentous complex on MRI is essential before a decision of instability is made. Burst fractures can be described as unstable if there is associated posterior ligamentous complex injury proved by MRI [82,87].

3. Nonoperative treatment

3.1. Indications

Initially, some series have reported poor outcomes from nonoperative management [7,29,33]. Denis et al [33] reported 6 cases of neurologic deterioration in 29 cases (of 39 cases originally examined), and nonoperative treatment was then believed to multiply the risk of neurologic deterioration. However, most investigators have found rare or no neurologic deterioration in initially neurologically intact patients [15,21,56,80,102], and neither was neurologic deterioration noted in the reported series [2,92,98,105].

Nonoperative treatment is most commonly indicated for a relatively stable burst fracture. Agus et al [2] concluded that neurologically intact 2- and 3-column injured Denis type A, B, and C thoracolumbar burst fractures with intact facet joints could be treated nonoperatively. Wood et al [105] and Tropiano et al [98] believed that nonoperative management is a safe method in treating neurologically intact patients with thoracolumbar burst fractures because of its acceptable functional and radiographic results. Similarly, Shen et al [91] demonstrated that neurologically intact patients with single-level closed burst fracture and no fracture dislocations or pedicle fractures can be treated nonoperatively. In these studies, radiographic parameters such as posterior column involvement, kyphotic angle, and degree of canal compromise were not used as indications for nonoperative treatment. However, these radiographic parameters were considered for the choice of the treatment in other studies. Hitchon et al [50] claimed that recumbency was generally adopted in fractures with an angular deformity less than 20°, a residual canal exceeding 50% of normal, and an anterior vertebral body height greater than 50% of the posterior height. In addition, the posterior ligament complex should be evaluated before a decision of management is made. Tezer et al [95] suggested that conservative management should only be considered if there is no neurologic deficit and the ligaments are intact.

There is a growing consensus that posttraumatic kyphotic deformity may cause back pain from the soft tissue surrounding the spinal deformity [67,99] and alterations in the biomechanical characteristics of the neighboring motion segments [44,62,81], so some authors plan the management based on the severity of kyphotic deformity. Reid et al [86] concluded that nonoperative treatment is indicated for neurologically intact patients with kyphotic angle less than 35°. In an effort to quantify the risk for late kyphosis progression in burst fractures, the SI was defined to help in assessing the segmental deformity at the level of the fracture [41]. The SI is a measurement of the kyphotic segmental deformity corrected for the normal sagittal contour at the level of the deformed segment. Farcy et al [41] proposed that nonoperative treatment would be indicated if the SI did not exceed 15°.

Load sharing classification is a reliable and easy-to-use classification for the conservative treatment. Aligizakis et al [6] suggested that conservative management should be limited to neurologically intact patients with load sharing scoring of 6 or less.

3.2. Canal remodeling and its clinical significance

Spontaneous remodeling of the spinal canal succeeding thoracolumbar burst fractures has been recognized as an entity after the advent of 3-dimensional imaging technologies [42]. The mechanism of canal remodeling
after burst fractures is resorption of the intracanal bone fragments, rather than subsequent changes in the position of those fragments. Therefore, remodeling is shown to occur in patients treated either operatively or nonoperatively [30,48,53,80,89,94,107]. The degree of canal remodeling has been reported by authors regarding either nonoperative or operative approaches [15,25,39,64,80,92,102]. It raises one question: Is operative treatment beneficial to canal remodeling? Yazici et al [107] reported that the resorption of retropulsed fragments was less favorable in nonoperatively treated patients, although spinal canal remodeling occurred in both operatively and nonoperatively treated patients. However, in another study, Dai [25] found that there were no differences of the percentage of remodeling between patients who were untreated and those treated nonoperatively and operatively.

It has been demonstrated that transpedicular intracorporal grafting in the treatment of burst fractures did not have a detectable effect on canal remodeling [4]. The sequela of remodeling seemed correlated with the initial canal encroachment [17,25]. Willen et al [104] demonstrated fragment resorption to some degree in 51% patients (20/39) who had initial canal narrowing of less than 50%, whereas larger fragments narrowing the spinal canal more than 50% did not appear to resorb. However, Mumford et al [80] reported significant remodeling in virtually all canals with greater than 50% compromise. Nonoperative treatment may be a choice for thoracolumbar burst fractures with canal encroachment without significant neurologic deficit regardless of the relation between remodeling and canal encroachment, because there was no correlation between the degree of canal compromise and any clinical symptoms. However, the choice of nonoperative management often means giving up decompression of the neural elements and poorer prognosis when the neurologic involvement is significant [25].

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of patients</th>
<th>Indication for nonoperative treatment</th>
<th>Follow-up</th>
<th>Functional results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aligizakis et al</td>
<td>60 (38 men, 22 women)</td>
<td>Neurologically intact patients with load sharing scoring of 6 or less</td>
<td>42 mo</td>
<td>Satisfactory: 91% Unsatisfactory: 9%</td>
</tr>
<tr>
<td>Celebi et al</td>
<td>26 (19 men, 7 women)</td>
<td>Single-level fracture without neurologic deficit, &lt;50% canal encroachment</td>
<td>42.9 mo</td>
<td>Excellent or good: 65.3% Poor: 7.7%</td>
</tr>
<tr>
<td>Denis et al</td>
<td>52</td>
<td>Fractures without neurologic deficit</td>
<td>42 mo</td>
<td>Neurologic deterioration: 17% Unable to return to work full time: 25%</td>
</tr>
<tr>
<td>Kinoshita et al</td>
<td>10 (8 men, 2 women)</td>
<td>Fractures with neurologic deficit</td>
<td>6 mo</td>
<td>Full recovery: 60% Neurological deterioration: none</td>
</tr>
<tr>
<td>Mumford et al</td>
<td>47</td>
<td>All middle column injuries with retropulsion of fragment in the bony canal, neurologically intact</td>
<td>2 y</td>
<td>Excellent: 49% Good: 17% Fair: 22% Poor: 12%</td>
</tr>
<tr>
<td>Reid et al</td>
<td>21</td>
<td>Neurologically intact, kyphotic angle less than 35°</td>
<td>18 mo</td>
<td>The change in kyphotic angle: 4.6° The change in anterior vertebral body crush: 6.1% The change in posterior vertebral body crush: −1.2% Satisfactory pain score: 100%</td>
</tr>
<tr>
<td>Shen et al</td>
<td>47 (23 men, 24 women)</td>
<td>Fractures without neurologic deficit</td>
<td>2 y</td>
<td>Kyphotic angle: 24° (21° at the time of admission) Canal compromise: 15% (34% at the time of admission) Able to return to work: 67% Satisfactory: 87% Unsatisfactory: 13%</td>
</tr>
<tr>
<td>Weinstein et al</td>
<td>42 (31 men, 11 women)</td>
<td>Anterior, middle and posterior column involvement Greater than 50% compression of the vertebral with anterior and posterior column involvement</td>
<td>20.2 y</td>
<td>Neurological deterioration: none; able to return to work: 88% Kyphotic angle: 26.4° in flexion and 16.8° in extension</td>
</tr>
<tr>
<td>Wood et al</td>
<td>23</td>
<td>Fractures without neurologic deficit</td>
<td>44 mo</td>
<td>Kyphotic angle: 13° (10.1° at the time of admission) Canal compromise: 19% (34% at the time of admission) Able to return to work: 83%</td>
</tr>
<tr>
<td>Authors</td>
<td>Type of study</td>
<td>No. of patients</td>
<td>Inclusion criteria</td>
<td>Follow-up</td>
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<tr>
<td>Dai et al [25]</td>
<td>Retrospective</td>
<td>24</td>
<td>Single-level nonpathologic burst fracture (T12-L2)</td>
<td>3-7 y</td>
</tr>
<tr>
<td>Denis et al [33]</td>
<td>Retrospective</td>
<td>52</td>
<td>Thoracolumbar fracture without neurologic deficit</td>
<td>36 mo (operative); 42 mo (nonoperative)</td>
</tr>
<tr>
<td>Hitchon et al [50]</td>
<td>Prospective</td>
<td>68</td>
<td>Thoracolumbar burst fracture (T12-L2) Indication for operation: angular deformity measured more than 10° and the residual spinal canal exceeded 50% of normal</td>
<td>21 mo (operative); 9 mo (nonoperative)</td>
</tr>
<tr>
<td>Shen et al [91]</td>
<td>Prospective</td>
<td>80</td>
<td>Neurologically intact patient, single-level closed burst fracture involving T11-L2, no fracture dislocations or pedicle fractures</td>
<td>2 y</td>
</tr>
<tr>
<td>Wood et al [105]</td>
<td>Prospective</td>
<td>47</td>
<td>Single burst-type thoracolumbar fracture without neurologic deficit (T10-L2)</td>
<td>44 mo</td>
</tr>
<tr>
<td>Yazici et al [107]</td>
<td>Retrospective</td>
<td>18</td>
<td>Thoracolumbar burst fracture</td>
<td>18-29 mo (operative); 18-24 mo (nonoperative)</td>
</tr>
</tbody>
</table>
3.3. Treatment modality

Conservative treatment consists of postural reduction, bed rest, body cast/orthosis, functional rehabilitation, or a combination of these. Although numerous authors have reported excellent results after nonoperative management without reduction [7,14,15,29,43,80,91,92,102], we claim to attempt to restore sagittal alignment by fracture reduction because a positive association was observed between kyphotic deformity and back pain. The duration of recumbency after fracture still remains controversial. Some authors recommended recumbency for 4 to 12 weeks followed by gradual mobilization, although some did suggest bed rest for a shorter time. Cantor et al [15] and Tropiano et al [98] reported satisfactory results from conservative treatment of neurologically intact burst fractures with early ambulation in a TLSO or casting. In addition, prolonged bed rest carries a risk of thromboembolism, decubitus ulceration, pulmonary complications, and patient deconditioning [15,98], and Willen et al [104] found no relationship between duration of bed rest and increase in gibbus angle in their series of 54 conservatively managed burst fractures. It seems that prolonged bed rest in these patients is unnecessary. Mumford et al [80] proposed standard treatment of 4 weeks of bed rest followed by 12 weeks of bracing for thoracolumbar burst fractures not accompanied by neurologic deficits.

3.4. Clinical outcome

Clinical outcome of conservative treatment of thoracolumbar burst fractures is summarized in Table 1. Although conservative treatment can lead to good clinical outcomes in neurologically intact patients with thoracolumbar burst fractures, it appears that the kyphosis progresses and vertebral body collapses gradually over time. Mumford et al [80] reported that kyphosis progressed 7° and anterior body collapsed a further 6% at an average follow-up of 2 years. Similarly, Willen et al [104] noted an average increase in kyphosis of 6° and a 7% increase in anterior body compression in a series of 54 patients at 6 months after fractures, whereas changes in both measurements were small 1 year after injury, suggesting stabilization of the deformity. Krompinge et al [60] reported that 36% of thoracolumbar burst fractures progressed 10° or more at follow-up. However, the remaining residual deformity was not correlated with symptoms at follow-up.

3.5. Nonoperative vs operative treatment

Clinical outcome of conservative treatment vs operative treatment of thoracolumbar burst fractures is summarized in Table 2. In general, patients with neurologic deficit are treated operatively, whereas the management of thoracolumbar burst fractures without neurologic deficit remains a matter of controversy. In a retrospective analysis of 104 cases of thoracolumbar burst fractures in the absence of neurologic deficit treated either operatively or non-operatively, Denis et al [33] found that all patients treated surgically had no unrelated disability and returned to full-time work, whereas 25% of the patients treated non-operatively were unable to return to work full time and 17% developed neurologic problems. This suggests the significant advantages of operative treatment over conservative management of thoracolumbar burst fractures without neurologic deficit. Theoretically, decompression, fracture reduction, and stabilization through surgery lead to optimal outcomes in terms of neurologic function and back pain [13,35]. However, most authors demonstrated that operative treatment of patients with a stable thoracolumbar burst fracture and normal findings on the neurologic examination provided comparable functional outcomes at long-term follow-up as compared with nonoperative treatment [25,37,58,91,105], although operative treatment may provide partial kyphosis correction and earlier pain relief [91]. In a prospective, randomized study comparing operative and nonoperative treatment of thoracolumbar burst fractures in 47 patients without neurologic deficit, radiographic examination demonstrated no significant differences between the 2 groups with respect to the fracture kyphosis on admission, after treatment, or after long-term follow-up [105]. Similarly, no significant difference was found between the 2 groups with respect to return to work and the average pain scores. In a retrospective study of 235 patients with unstable thoracolumbar fractures, Rechtine et al [84] found that there was no significant difference in the occurrence of decubitus, deep venous thromboses, pulmonary emboli, or mortality between the nonoperatively treated patients and operatively treated patients. However, we must note that the average charges related to hospitalization and treatment in patients treated operatively are much greater than those in patients treated nonoperatively. Taken together, nonoperative treatment remains a viable alternative to operative intervention in neurologically intact patients with thoracolumbar burst fractures, although there is definitely a need for randomized controlled trials with sufficient sample size to determine whether one treatment is more effective than the other.

4. Operative treatment

The goals of surgical treatment of thoracolumbar spinal fractures include (1) decompression of the spinal canal and nerve roots to facilitate neurologic recovery, (2) restoration and maintenance of vertebral body height and alignment, (3) obtaining a rigid fixation to facilitate nursing care and to allow early ambulation and rehabilitation, (4) prevention of development of posttraumatic progressive deformity with neurologic deficit, and (5) limiting the number of instrumented vertebral motion segments [1,18,52]. Recent trends have been toward rigid internal fixation of fractures to allow rapid mobilization of patients and decrease the complications of prolonged immobilization of joints and muscles.
4.1. Indications

Generally, operative management is indicated in patients who present with a neurologic deficit and an unstable burst fracture. One notable exception is patients with an isolated partial nerve root deficit, which usually will improve in time with nonsurgical treatment. Reid et al [86] concluded that it is necessary to treat patients operatively with burst fractures if these patients have neurologic deficits or kyphotic angle more than 35°. Benson et al [11] and Willen et al [104] concluded that operative treatment should be limited to those fractures with canal compromise more than 50%, compression rate of the anterior column exceeding 50%, and kyphotic angle more than 20°. There was no correlation between the degree of canal compromise and any clinical symptoms. Thus, in the setting of a detailed neurologic examination with normal findings, no degree of canal compromise would by itself serve as an indication for operative intervention and decompression in this fracture [105]. Nowadays, there is a growing consensus that there might be a positive association between kyphotic deformity and back pain [37,41,46], so kyphotic deformity should serve as an indication for surgical management. SI is a useful criterion to assess deformity and predict progression of segmental kyphosis. Farcy et al [41] proposed that if the SI exceeds 15°, the biomechanical environment favors progression of kyphosis, and surgery is indicated. In addition, if the posterior ligamentous complex is injured, surgical management should be undertaken [95].

If patients have certain situations, such as obesity, skin conditions, multitrauma, and psychological factors, operative treatment should be considered because either casting or bracing is not feasible or surgical stabilization is advantageous.

4.2. Operative approach

If surgical treatment of thoracolumbar burst fractures is chosen, further debate arises from the appropriate type of approach. There are 3 major approaches used in the treatment of patients with thoracolumbar burst fracture [10,13,36,61,90]. The anterior approach with a plate on the vertebral body provides good decompression and solid fusion, but the operative risk is relatively higher than that associated with the posterior approach [39,54]. The posterior procedure of the thoracolumbar junction is well established, with advantages such as more safety in exploring the surgical site without violating the pulmonary, visceral, and vascular structures [75] and being less technically demanding. However, instrument failure and recurrence of kyphosis have been reported when surgery is made without vertebral body reconstruction [16,38,73]. One of the treatment modalities to solve these problems is long-segment pedicle screw fixation (2 above and 2 below), but this will reduce the range of spinal motion. A combination of the anterior and posterior approaches may be an ideal method, but the operative time is longer and the surgical trauma is higher. The question as to how these fractures should be approached and stabilized (anteriorly, posteriorly, or combined anteroposteriorly), remains controversial [27,33,40,45,46,49,65].

Anterior decompression and stabilization has been proposed for cases with severe canal compromise, vertebral comminution, and kyphotic deformity, and especially with neurologic deficit [49,72]. In cases without neurologic deficits, however, most authors recommend indirect reduction with posterior transpedicular instrumentation. McCormack et al [71] introduced the load-sharing classification system, which is assessed to accumulate the points for a total score as determined by the vertebral fracture anatomy: (1) the amount of comminution on sagittal CT scans: 1 point for little comminution when 30% or less of the vertebral body is involved, 2 points when 30% to 60% of the body is involved, and 3 points for greater than 60% comminution of the vertebral body; (2) the amount of displacement of fracture fragments on axial CT scans: 1 point for minimal displacement, 2 points for at least 2 mm displacement less than 50% of the cross-sectional area of vertebral body, and 3 points for 2 mm or greater displacement in more than 50% of the cross-sectional area; (3) the amount of correction of kyphotic deformity on lateral plain radiographs: 1 point for 3° or less correction, 2 points for 4° to 9° correction, and 3 points for 10° or more correction. Parker et al [83] applied this system and were able to predict which fractures could be safely treated with short-segment transpedicular posterior instrumentation with low risk of screw failure or progressive deformity. High-risk fractures should be treated in an alternative manner, using either an anterior strut graft or longer instrumentation.

4.3. Posterior surgery

Burst fractures are caused by flexion-axial loading forces and thus seem best treated posteriorly with reduction and fixation by extension and distraction. A variety of instrumentation systems is available, and attachment can be achieved and forces applied to the spine by hooks, rods, wires, and/or screws. In general, hook-rod systems require longer moment arms over more instrumented segments than do pedicle screw constructs. The efficacy of relatively long fusions with segmental hook-rodd constructs is well documented. McBride [70] obtained a 93% fusion rate in 48 thoracolumbar fractures using multiple hook-rod fixation with a follow-up of 21 months. A 22% complication rate was noted because of early hardware failure, persistent pain, syrinx formation, and progression of scoliotic deformity. Sublaminar or interspinous wire fixture is rarely used in trauma patients, aside from some with complete cord injuries, because wire passage can cause additional trauma to the spinal cord, especially after fracture. Pedicle screw instrumentation systems are most commonly used today. Theoretically, pedicle screw fixation allows greater forces to be applied to the spine to reduce deformity because of its 3-column fixation characteristics, which facilitate simultaneous application of axial compression or distraction and
rotational forces. The improved stiffness of pedicle screw constructs may allow some burst-type fractures to be treated with very short constructs one level above and below the fracture. Markel and Graziano [68] demonstrated that some thoracolumbar burst fractures could be treated successfully with short-segment fixation in comparison with longer instrumentation and fusion. Similarly, Parker et al [83] reported a 98% fusion rate and no significant loss of lordosis with the use of short transpedicular fusion in burst fractures without extensive kyphosis or comminution. However, there was a 20% to 50% incidence of implant failure and a 50% to 90% loss in reduction of kyphosis [16,38,73,74]. Therefore, in patients with extensive comminution and kyphosis or those who are unable to comply with postoperative bracing, alternative surgical methods may be indicated. Long-segment posterior fusion has yielded more than 90% fusion rates [70]; at least 2 levels above and below the fracture are usually instrumented. Nowadays, controversy still exists over whether short-segment pedicle instrumentation is a suitable method. In a randomized controlled trial, Tezeren and Kuru [96] reported that 5 of 9 patients treated with short-segment instrumentation had a correction loss of 10° with a 55% failure rate, whereas none of the patients had a correction loss of 10° in patients treated with long-segment instrumentation.

Spinal fusion has always been a part of the stabilizing procedure. In theory, this may result in a decreased rate of implant failure. However, in a retrospective study of 28 consecutive patients who had short-segment pedicle screw fixation of thoracolumbar burst fractures without fusion performed, the implant failure rate and the clinical outcome were similar to that from series where fusion had been performed in addition to pedicle screw fixation [16,39,88]. Furthermore, bone grafting does not decrease the loss of correction after surgery [57]. It seems that bone grafting is not necessary when managing patients with thoracolumbar burst fractures by short-segment pedicle screw fixation. Potential advantages without fusion are that the facet joints are less disturbed adjacent to the fracture, with reduced surgical soft tissue stripping being required when a bed for the graft does not have to be prepared, and thoracolumbar motion is preserved.

Although short-segment fixation is the most common and most simple treatment of burst fractures [59] without anterior construction, the loss of restoration will be greater because of the recollapse of the disk space. Transpedicular grafting of the injured anterior vertebral body in addition to short-segment fixation has been offered as a possible solution by Daniaux [26]. This theoretically supplements the middle column, thus decreasing the correction loss. In addition, this method decreases the bending moments on the posterior instrumentation and may result in a decreased rate of screw breakage [38]. However, a prospective trial of transpedicular intracorporeal grafting with short-segment instrumentation for thoracolumbar fractures failed to find a benefit compared with short-segment pedicle screw fixation with only fusion, and both procedures had high failure rates of 40% to 50%, as defined as an increase of 10° or more in local kyphosis and/or screw breakage [5]. Transpedicular bone grafting has also been demonstrated not to decrease the loss of correction [57], suggesting that transpedicular grafting of the injured vertebral body is not effective in preventing correction loss and implant failure, although it appears to be a safe procedure. In addition, posterior body reinforcement with cement has been applied to restore and maintain the vertebral body and minimize implant failure in short-segment fixation. Mermelstein et al [75] found in their cadaveric burst fracture study that vertebroplasty with calcium phosphate cement reinforced the anterior column and reduced stress on the pedicle screw construct. In addition, this technique has been demonstrated relatively effective in preventing reduction loss and avoiding implant failure in clinical studies [19,20,22,63,101]. Toyone et al [97] reported a mean correction loss of 2° in their series using transpedicular hydroxyapatite grafting after indirect reduction and pedicle screw fixation, which was similar to those of the series of anterior decompression and stabilization with the Kaneda device (1°) [54] and Z plate (2°) [72]. Cho et al [20] reported that kyphosis correction (0.33° vs 6.2° loss) and anterior vertebral height (12.9% vs 2.3%) were achieved and maintained in fractures reinforced with PMMA cement during surgery, but not in fractures treated without PMMA vertebroplasty at about 2 years follow-up, and in the control of severe and constant pain, short-segment pedicle screw fixation combined with PMMA vertebroplasty has better clinical outcome than simply short-segment pedicle screw fixation. PMMA cement offers immediate spinal stability in patients with thoracolumbar burst fractures, as does anterior plate and screw fixation performed for anterior column repair. In addition, the increased vertebral body height and hardness achieved with the use of PMMA cement may change the loading force on the anterior column and decrease the stress on the posterior instruments [75]. That is why in patients treated with PMMA vertebroplasty, the kyphosis correction can be maintained with minimal loss of vertebral height, a low instrument failure rate, and better postoperative pain control. The vertebroplasty procedure, however, is not an absolutely safe procedure; it inherits potential risks of extravasation of PMMA. Therefore, it is important to note that not every thoracolumbar burst fracture can be treated by vertebroplasty procedure. After conservative treatment, the neurologically intact patients with thoracolumbar burst fractures had intractable pain, the fractures were limited to within the anterior and middle column, and the posterior longitudinal ligament was intact. In the above circumstances, the vertebroplasty can be considered for treatment of burst fractures.

Decompression with laminectomy alone has been shown to be of no value and has been rightly abandoned because it became evident that posterior laminectomy not only failed to decompress the spinal canal, as most of the compression
was anterior, but that in fact made many patients worse by destabilizing the spine, causing increased kyphosis and placing more pressure on the anterior part of the spinal cord and nerve roots.

4.4. Anterior surgery

With the use of the computer-assisted axial tomographic scanner, it has become readily apparent that distraction rods or compression rods do not routinely decompress the bone fragments from residual impingement on the neural elements in the spinal canal. In contrast to the loss of angulation after posterior instrumentation [57], some authors have reported on anterior procedures resulting in a minimal loss of sagittal alignment in clinical studies [8,49,54,77]. In addition, biomechanical studies have proven the advantage of anterior procedures, providing superior rigidity as compared with posterior instrumentation [66,93,100,108]. Thus, this has resulted in a new controversy regarding the necessity of anterior decompression and possibly the efficacy of anterior procedures. Currently, several authors advocate a primary anterior approach to the fractured vertebra, debridement of the fracture fragments from the anterior aspect of the spinal canal, and the use of bone grafts or anterior transvertebral-body internal fixation devices to provide stability. In most patients with thoracolumbar fractures, neurologic deficit is caused by impact and/or compression to the ventral surface of the spinal cord, and the anterior approach provides optimal direct exposure for visualization of the ventral aspect of the dura mater during surgical decompression. In addition, for fracture patterns involving marked comminution with loss of support of the anterior and middle columns of the spine, the anterior approach provides excellent exposure for reconstruction with structural grafts or implants. This allows restoration of height and correction of kyphosis while limiting the number of motion segments fused. The anterior approach can be used for both management of the neurologic deficit and restoration of stability to the spine, but on the other hand, this is surgically more challenging and has a greater potential for complications.

Clinical results of the anterior instrumentation in treating thoracolumbar burst fractures have been well documented in many studies [72]. McAfee et al [69] reported that 37 of 42 patients treated with anterior decompression and instrumentation at a mean of 60 days after initial injury had some degree of neurologic improvement. Of the 37 patients, 30 preoperatively had motor strength of grade 3 or less. Fourteen of these 30 patients became community ambulators; 9 others regained function adequate for household ambulation, although some required short leg braces and/or crutches. Radiographic results indicated that 12 of the 42 patients developed kyphosis of more than 20° postoperatively. Similarly, in a retrospective study of 35 patients with thoracolumbar burst fractures treated with anterior surgery, strut graft, and fixation with a Z plate, all 16 patients with neurologic deficit demonstrated at least one Frankel grade improvement 2 years after surgery, with 11 (69%) patients demonstrating complete neurologic recovery [72]. Ghanayem and Zdeblick [47] reported on a small series of 12 patients treated with anterior instrumentation for thoracolumbar burst fractures, with 11 of the 12 obtaining a good or excellent functional outcome and a solid arthrodiesis.

Comparative studies between the anterior and posterior approaches are relatively few. In a randomized prospective comparison of these 2 approaches in a population of 40 patients with a mean follow-up of 20 months, Esses et al [39] reported no particular difference between the 2 approaches in restoring normal sagittal contour, but did note 2 implant failures of 20 anterior procedures and that the blood loss was significantly higher in the patients undergoing anterior surgery. However, there were no complications from the thoracotomy. The limitation of this study was that their analysis was limited to the radiographic and perioperative parameters only. Wood et al [106] performed a randomized prospective comparison of the 2 surgical approaches in 38 patients followed up for a mean of 2 years, they reported similar patient outcomes between the 2 approaches, and that anterior fusion and instrumentation for thoracolumbar burst fractures may present fewer complications or additional surgeries. The current studies do not provide a reliable answer to whether anterior or posterior surgery is more effective in treating thoracolumbar burst fractures. High-quality randomized controlled trials are needed.

4.5. Combined anteroposterior surgery

Some authors proposed the combined anteroposterior approach in treating thoracolumbar burst fractures. However, in a retrospective comparison of the combined anteroposterior approach and the posterior approach alone with a follow-up of 6 years, Been and Bouma [9] reported no significant difference in neurologic outcome between the 2 approaches, although the combined anteroposterior approach yielded the best results in long-term maintenance of kyphosis correction. Posterior distraction and short-segment instrumentation was followed by loss of reduction to some degree, but the long-term kyphotic angle (4°) was acceptable, and was not associated with a higher incidence of pain. Similarly, in another retrospective study of 49 patients treated with the anteroposterior procedure, anterior procedure, or posterior procedure, Danisa et al [28] reported that combined surgery required the longest total operative time and is associated with the most intraoperative blood loss, and patients treated with anteroposterior surgery fared no better in neurologic recovery, correction of spinal deformity, fusion healing, pain relief, or work status than those treated with anterior surgery or posterior surgery. These results suggest that the combined anteroposterior approach has no obvious advantages over the anterior or posterior approach alone, but this really invokes an extensive surgical procedure. Therefore, we do
References


not recommend combined anteroposterior surgery in treating thoracolumbar fractures because better and more cost-effective results can be obtained through other procedures.


Dr. Dai and colleagues have performed an extensive review regarding the treatment of thoracolumbar burst fractures. This was not a meta-analysis, rather this manuscript presents a summary of treatments, both surgical and nonsurgical, as presented in the literature. The review of nonoperative treatments is excellent, and this is generally not expounded upon in the surgical-based literature. The indications for surgical approaches and the approaches themselves are also well reviewed as based on the literature. Whereas this manuscript leaves the reader with few definite conclusions, it does provide an excellent foundation for the decision-making process and may foster the generation of class I evidence in the future.
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