Anterior thoracolumbar locked plate fixation for the treatment of an acute unstable burst fracture of the thoracic and lumbar spine

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Background
In unstable burst fractures of the thoracic and lumbar spine, short segmental posterior fixation has been associated with a high rate of hardware failure, with recurrence of deformity. Anterior surgical treatment allows direct decompression of the neural elements and reconstruction of the weight-bearing column with fusion of only two levels.

Aim of the work
The aim of this study was to evaluate the effectiveness of anterior-only surgery and locked plate fixation in the treatment of unstable burst fractures of the thoracic and lumbar spine.

Study design
Prospective study.

Patients and methods
We included 22 patients (13 men and nine women) with acute thoracolumbar burst fractures treated with anterior surgery, strut iliac graft, and fixation with a locked thoracolumbar plate. The mean age of the patients at the time of surgery was 33.2 years (range 19–55 years). Neurologically, five patients were Frankel B, 13 were Frankel C, and four were Frankel E. All patients had preoperative and postoperative radiographs and computed tomography scan.

Results
The 18 patients with neurological deficit showed at least one Frankel grade improvement on final observation, with 16 (88.9%) patients showing complete neurological recovery. Sagittal alignment was improved from a mean preoperative kyphosis of 19.9–6.7° at the final observation.

Conclusion
Through the anterior surgery of the spine and locked plate fixation, we can achieve good canal decompression, spinal column alignment, and short segment arthrodesis.

Keywords:
anterior corpectomy, anterior locked plate, burst fractures, thoracolumbar fractures

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Introduction

Unstable fractures of the thoracic and lumbar spine often require internal fixation. Stabilization of these injuries has many advantages including early mobilization and the potential for neurologic improvement. Optimal treatment of these injuries is controversial. Although some surgeons prefer to utilize posterior indirect decompression and instrumentation techniques, others advocate an anterior-only approach to directly decompress the neural element, followed by internal fixation. Still others recommend a combined anterior and posterior approach [1].

The development of posterior pedicle screw segmental instrumentation has allowed more rigid fixation [2–4]. Using posterior distraction, canal encroachment is improved indirectly by ligamentotaxis. Alternatively, a transpedicular or a costotransversectomy decompression technique can be used [5]. Canal decompression is limited and often incomplete. In addition, short segmental fixation has been associated with a high rate of hardware failure, with recurrence of deformity (Fig. 1) [6–8]. This led some surgeons to advocate combined anterior and posterior approaches [9–12]. More recently, corpectomy, followed by the placement of a structural bone graft and anterior instrumentation has allowed direct reconstruction of the weight-bearing column and fusion of only two levels [2,3,5,13–16]. McCormak *et al.* [17] have advanced a classification system on the basis of load sharing in an attempt to predict which fracture will fail. The proportion of vertebral body damage, spread of fracture fragments, and the amount of corrected traumatic kyphosis are the three factors found to be important in predicting failure [17]. Anterior short segment instrumentation is biomechanically stronger in every loading condition compared with short segment posterior pedicle screw instrumentation and may be the most reliable method to achieve optimal decompression and short segment stabilization [1,12]. Anterior spinal instrumentation systems have the potential advantage of preserving additional motion segments by instrumentation of fewer vertebrae.

Figure 1

Anterior thoracolumbar locked plate.

Anterior procedures may lead to greater correction through direct manipulation of the vertebral body. However, correction by fusing fewer segments may increase the stress within the instrumentation construct, particularly at the bone– screw interface [18]. In our department, we have previously used nonlocked plates in anterior fixation of the dorsolumbar spine. Recently, we introduced an anterior locked thoracolumbar plate system used in these types of fractures. The objective of this study was to examine the effectiveness of the anterior-only surgical treatment of thoracolumbar burst fractures, with a focus on neurologic recovery and restoration of spinal alignment and stability using anterior thoracolumbar locked plates.

Patients and methods

The study included 22 patients with thoracic and lumbar unstable burst fractures treated with anterior surgery, strut graft, and fixation with a locked thoracolumbar plate system in an acute setting from July 2005 to October 2007.

All patients had acute unstable spinal burst fractures between T6 and L3. The patients included 13 men and nine women aged 19–55 years (mean 33.2 years). Surgical indications were acute unstable burst fractures with a load-sharing classification score of more than 6 points (Fig. 2) and significant retropulsed fragments into the canal (i.e. >50% spinal canal impingement) [17]. Neurological status was classified using the Frankel classification [19]. None of the patients showed complete neurological deficit and four patients were neurologically free. All patients had preoperative anteroposterior and lateral radiographs (Fig. 3a and b) and computed tomography (CT) scan (Fig. 1c). The fracture levels were one T6, two T7, one T9, one T10, three T12, seven L1, three L2, and four L3; no fractures of L4 or L5 were managed by the anterior approach.

The kyphotic angle was measured in supine lateral radiographs before surgery and standard lateral radiographs in the postoperative inpatient stay and at the final follow-up examination. It was recorded using the Cobb technique as the angle between the superior end plate of the vertebral body above the affected level and the inferior end plate of the vertebral body below the level. Radiographic measurements included a determination of percentage of canal compromise from the axial CT scan (Fig. 3c). This determination was carried out using the following formula in the axial CT of the spinal canal:

$$\frac{\left[\frac{A+C}{2}\right]-B}{\left[\frac{A+C}{2}\right]}\times 100$$

where A is the anteroposterior distance of the canal above, B is that of the fractured canal, and C is that of the canal below [8]. Load-sharing classification depends on the degree of comminution in sagittal CT (3 points), the spread of comminution and apposition of body fragments in axial CT scan (3 points), and the measurement of how many degrees are needed to correct the kyphotic deformity in the lateral radiograph (3 points). A structural iliac strut graft was performed for all patients. The mean surgical time was 156.8 min (120–240). The mean hospital stay was 5.7 days. A thoracolumbar brace was fitted after surgery for 3 months. All patients were followed for a minimum of 1.5 years, with a mean follow-up period of 21.9 months.

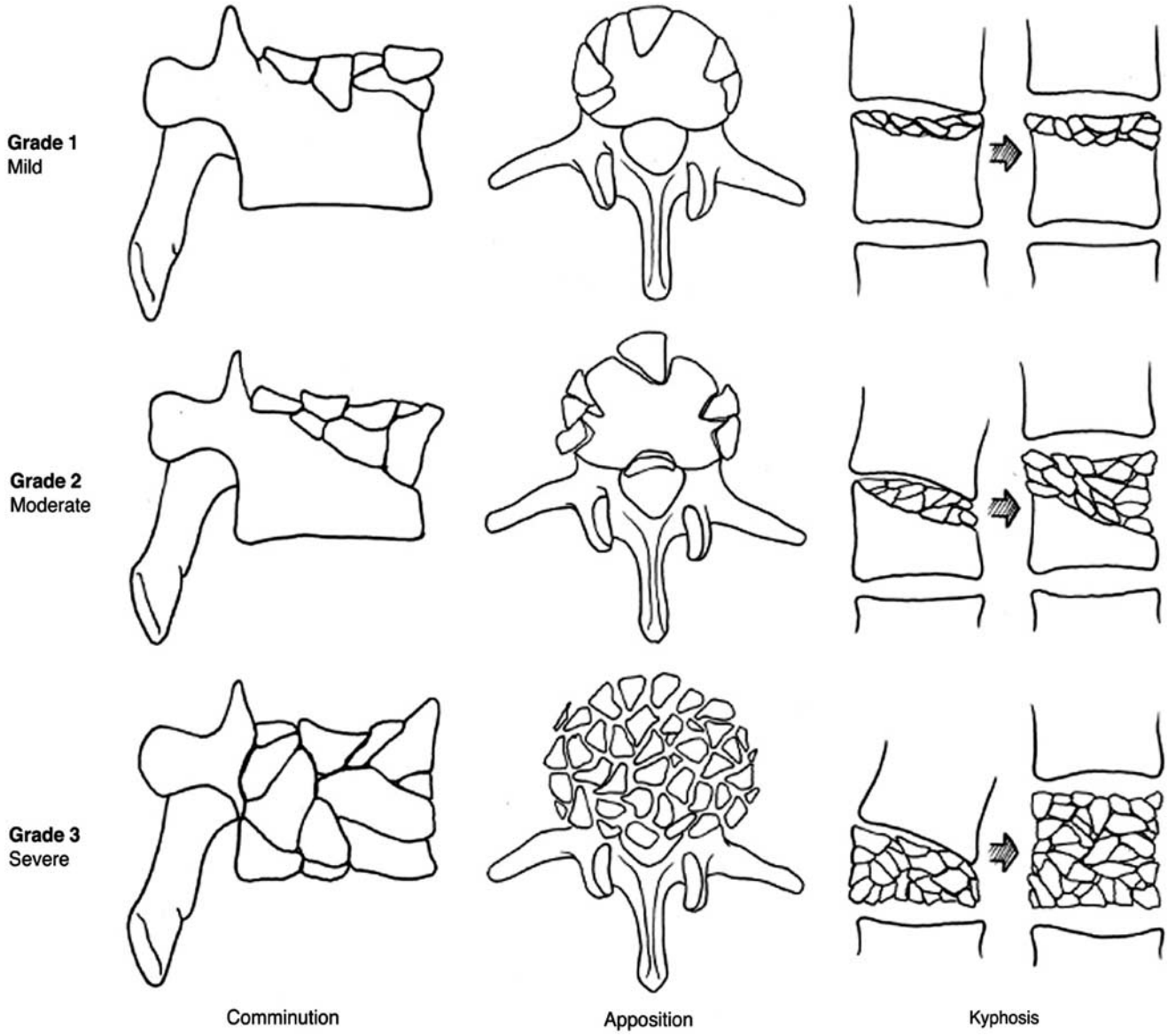
Results

Clinical results

Eighteen patients (81.9%) had a neurological deficit; five patients were Frankel grade B and 13 were Frankel grade C. All 18 patients showed neurological improvement at the final follow-up observation. Sixteen of these patients showed full neurological recovery. Two patients with Frankel grade B improved to grade C. The remaining four patients (18.1%) who were neurologically free did not show any neurological deterioration. In terms of bladder and bowel function at the last follow-up, the two patients who improved to Frankel grade C did not show any bladder and bowel improvement.

According to the Denis scale of pain and work status, 18 patients (81.9%) reported no or minimal pain (P1 + P2)

Figure 2



Load-sharing classification.

and four (18.1%) reported moderate pain (P3). None reported severe pain (P4 + P5). Twenty patients (90.9%) returned to their work and normal activity [20].

Radiological results

The mean preoperative kyphosis was 19.9° (range −10 to 36°); this improved to a mean of 3.4° (range −14 to 20°) kyphosis in the first postoperative radiograph, which means that the degree of angle gain was 16.5° (Fig. 3d and e). The final radiographs showed a mean of 6.7° (range −10 to 22°), which means that the degree of angle loss was 3.3° that developed as fractures healed (Fig. 3h and i).

CT was performed for all patients preoperatively and postoperatively. The mean degree of spinal canal compromise was 44.7% (range 10–91%). The number of patients with significant canal compromise (>50%) was 12 (54.5%). All patients with neurological deficits (18 patients) were decompressed intraoperatively, whereas two of the four neurologically free patients were decompressed because they had significant canal compromise (Fig. 3f and g).

Complications

There was only one patient who showed superficial wound infection, which improved with daily dressing and antibiotics. There were no cases of hardware breakage, CSF leakage, pneumothorax, hemothorax, vascular injury, incisional hernia, or diaphragmatic rupture.

Discussion

Currently, there are no conclusive clinical studies available to help surgeons decide on the optimal surgical treatment for thoracolumbar burst fractures [13]. The goals of surgical treatment of unstable thoracolumbar

Figure 3

Radiographs of (a) preoperative anteroposterior plane. Male, 34 years, burst fracture, L3, Frankel C; (b) preoperative lateral plane. LKA: 4°; (c) Preoperative computed tomography, 91% canal compromise; (d) postoperative anteroposterior plane; (e) postoperative lateral plain. LKA: −12°; (f) Postoperative computed tomography, good canal decompression; (g) postoperative computed tomography, position of screws in the body; (h) last follow-up anteroposterior plane; (i) last follow-up lateral. Frankel E, LKA: −9°. LKA, local kyphotic angle.

burst fractures are to decompress the neural tissue, facilitating neurological recovery, restore vertebral body height and alignment, allow rapid rehabilitation and mobilization, prevent the development of progressive deformity with neurologic deficit, and limit the number of immobilized spinal motion segments [21].

Posterior stabilization techniques using the transpedicular screw fixation system have the disadvantages of length of the instrumentation (requiring immobilization of five motion segments). Advances in spinal instrumentation have led to the development of short segment spinal instrumentation to avoid fusion of uninjured motion

segments. However, McLain and colleagues have reported a failure rate of posterior short segment pedicle instrumentation ranging from 10 to 50%. After fracture reduction by posterior ligamentotaxis, the load-bearing anterior column is not reconstructed. The void created by indirect reduction eliminates anterior column load sharing and exposes pedicle screw implants to high cantilever bending loads [6,14,15]. McCormak *et al*. [17] have advanced a classification system on the basis of load sharing in attempt to predict which fractures will fail with only a short segment posterior pedicle screw construct. Therefore, reconstruction of the defect in the anterior and middle columns is mandatory. Bone grafting alone is usually insufficient to provide stability; thus, either anterior or posterior instrumentation is frequently needed. A two-stage technique of posterior stabilization combined with anterior decompression and grafting was developed. The desire to decrease surgical morbidity and duration precipitated the development of anterior instrumentation and allowed treatment by a single-stage procedure. Bone *et al*. [22] have reported that the broad dynamic compression plate with the 4.5 mm screws provides stiffness in axial and torsional loading. Dunn [23] developed an anterior device with initial success. Kostuik [7] had success with anterior decompression and stabilization with the Kostuik–Harrington device. However, the hardware failure rate was 16%. Kaneda *et al*. [16,24] developed an anterior device that combined two vertebral staples and two cross linked longitudinal rods. Kaneda *et al*. [16,24] reported a 95% rate of neurologic improvement of at least one Frankel grade, 7% pseudoarthrosis rate, and 6% hardware breakage rate. An iliac crest autograft was used as the structural graft in this series. The use of anterior instrumentation has been supported by biomechanical research [3,4]. Using a dog model, Zdeblick *et al*. [11] reported an increased fusion rate and stiffness with Kaneda instrumentation compared with treatment with a bone graft alone.

Anterior instrumentation has been compared with more extended posterior instrumentation. With in-vitro testing of calf spine, Gurr *et al*. [4] found a similar stiffness between a five-level posterior pedicle screw construct and a three-level Kaneda construct [4]. Further development has led to the production of devices such as the locked plate. This device was constructed of titanium, had a lower profile, and was simpler in its surgical technique. In addition, it was designed with the goals of dynamic capabilities, with decreased construct failure. Cloutier *et al*. [25] have reported that the anterior instrumentation should be put in place with the axis of the screw aligned as close as possible with the coronal plane to increase the final stiffness. Bicortical grip on bones should also be used [25].

This study found a 100% neurological improvement of at least one Frankel grade in patients with neurological deficits at the final follow-up without any postoperative neurological deterioration. The final functional outcomes of both pain and return to work were satisfactory and compare favorably with previous outcomes. Reconstruction with an iliac strut graft and augmentation with a locked thoracolumbar plate fixation yielded a successful 100% fusion rate. The average kyphotic angle improved from 19.9 to 3.4° immediately postoperatively and 6.6° at the last follow-up. Actually, posterior instrumentation allows better angle correction than anterior-only surgery, but it did not affect the clinical outcomes in terms of neurology, back pain, and return to work and normal activity in this study. There was a single complication, a superficial wound infection in one patient, who improved conservatively on antibiotics and daily dressing.

Conclusion

Through the anterior surgery of the spine, corpectomy, iliac graft, and anterior fixation with a locked plate-screw system, we can achieve the three goals of surgery in thoracolumbar fractures with or without neurological deficits: good decompression of the spinal canal, restoration of spinal column alignment, and successful arthrodesis of the injured segments.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

References

1 Sasso RC, Renkens K, Hanson D, Reilly T, McGuire RA Jr, Best NM. Unstable thoracolumbar burst fractures: anterior-only versus short-segment posterior fixation. J Spinal Disord Tech 2006; 19:242–248.

2 Carl AL, Tromanhauser SG, Roger DJ. Pedicle screw instrumentation for thoracolumbar burst fractures and fracture dislocations. Spine 1992; 17:5317–5324.

3 Gaines RW, Carson WL, Satterlee CC. Experimental evaluation of seven different spinal fracture internal fixation devices using non failure stability testing. The load sharing and unstable-mechanism concepts. Spine 1991; 16:902–909.

4 Gurr KR, Mcafee PC, Shih CM. Biomechanical analysis of anterior and posterior instrumentation system after corpectomy. A calf spine model. J Bone Joint Surg Am 1988; 70:1182–1191.

5 Zdeblick TA, Shirado O, McAfee PC. Anteior spinal fixation after lumbar corpectomy. A study in dogs. J Bone Joint Surg Am 1991; 73A: 527–534.

6 Hashimoto T, Kaneda K, Abumi K. Relationship between traumatic spinal canal stenosis and neurologic deficit in thoracolumbar burst fractures. Spine 1988; 13:1268–1272.

7 Kostuik JP. Anterior fixation for burst fractures of the thoracic and lumbar spine with or without neurological involvement. Spine 1988; 13:286–293.

8 Foster RW. CT of the spinal trauma. Spine 1988; 2:427.

9 Kirshblum SC, Memm OP, Kim N. Comparison of the 2000 American spinal injury association standards with the guidelines. Am J Phys Med Rehabil 2002; 81:502–505.

10 An HS, Vaccaro A, Colter JM. Low lumbar burst fractures: comparison among body cast, Harrington rod, Luque rod and Steffee plate. Spine 1991; 16:440–444.

11 Zdeblick TA, Dick JC, Bartel BD. Anterior instrumentation of the thoracolumbar spine: a biomechanical comparison. Spine 1997; 22:744–750.

12 Shono Y, McAfee PC, Cunningham BW. Experimental study of thoracolumbar burst fractures. Radiographic and biomechanical analysis of anterior and posterior instrumentation systems. Spine 1994; 19: 1711–1722.

13 Vaccaro AR, Lim MR, Hurlbert RJ. Surgical decision making in unstable thoracolumbar spine injuries: result of a consensus panel review by the spine trauma study group. J Spinal Disord Tech 2006; 19:1–10.

14 McLain RF, Sparling E, Benson DR. Early failure of short segment pedicle instrumentation for thoracolumbar fractures. J Bone Joint Surg Am 1993; 75:162–167.

15 An HS, Lim TH, You JW. Biomechanical evaluation of anterior thoracolumbar spinal instrumentation. Spine 1984; 9:788–795.

16 Kaneda K, Abumi K, Fujiya M. Burst fractures with neurologic deficits of the thoracolumbar spine: results of anterior decompression and stabilization with anterior instrumentation. Spine 1984; 9:788–795.

17 McCormak T, Karaikovic E, Gaines R. The load sharing classification of spine fracture. Spine 1994; 19:1741–1744.

18 Seller K, Wahl D, Wild A, Krauspe R, Schneider E, Linke B, *et al*. Pull out strength of the anterior spinal instrumentation; a product comparison of seven screws in calf vertebral bodies. Eur Spine J 2007; 16:1047–1054.

19 Frankel HL, Hancock DO, Hyslop G, Melzak J, Michaelis LS, Ungar GH, *et al*. The value of postural reduction in the initial management of closed injuries with paraplegia and tetraplegia. Paraplegia 1969; 7:179–192.

20 Denis F, Armistrong GW, Searls K, Malta L. Acute thoracolumbar burst fractures in the abscence of neurological deficit: a comparison between operative and non operative treatment. Clin Orthop Relat Res 1984; 189: 142–149.

21 Abei M, Etter C, Kehl T. Stabilization of the lower thoracic and lumbar spine with the internal spinal skeletal fixation system: indications, techniques and first results of treatment. Spine 1987; 12:544–551.

22 Bone LB, Johnston CE, Asman RB, Roach JW. Mechanical comparison of anterior spinal instrumentation in a burst fracture model. J Orthop Trauma 1988; 2:195–201.

23 Dunn HK. Anterior stabilization of thoracolumbar injuries. Clin Orthop 1984; 189:116–124.

24 Kaneda K, Tanechi H, Abumi K. Anterior decompression and stabilization with the Kaneda device for thoracolumbar burst fractures associated with neurologic deficits. J Bone Joint Surg Am 1997; 79:69–83.

25 Cloutier LP, Aubin CE, Grimard G. Biomechanical study of anterior spinal instrumentation configurations. Eur Spine J 2007; 16:1039–1045.