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Comparison of two Types of Surgery for Thoraco-Lumbar Burst Fractures: Combined Anterior and Posterior Stabilisation vs. Posterior Instrumentation Only

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Summary

This retrospective study compares clinical outcome following two different types of surgery for thoracolumbar burst fractures. Forty-six patients with thoracolumbar burst fractures causing encroachment of the spinal canal greater than 50% were operated on within 30 days performing either: combined anterior decompression and stabilisation and posterior stabilisation (Group 1) or posterior distraction and stabilisation using pedicle instrumentation (AO internal fixator) (Group 2). We evaluated: neurological status (Frankel Grade), spinal deformities, residual pain, and complications. The average follow-up was 6 years. There were no significant differences between the patients in both groups concerning age, sex, cause of injury and the presence of other severe injuries. Neurological dysfunction was present in 39% of all cases. Bony union occurred in all patients. Loss of reduction greater than 5 degrees and instrumentation failure occurred significantly more often in Group 2 compared to Group 1, but the kyphosis angle at late follow-up did not differ between groups, due to some degree of overcorrection initially after surgery in Group 2. The clinical outcome was similar in both groups, and all but one patient with neurological deficits improved by at least one Frankel grade.

Indirect decompression of the spinal canal by posterior distraction and short-segment stabilisation with AO internal fixator is considered appropriate treatment for the majority of unstable thoracolumbar burst fractures. This is a less extensive surgical procedure than a combined anterior and posterior approach.

Keywords: Thoraco lumbar spinal fractures; outcome; surgical technique; spinal instrumentation.

Introduction

Thoracolumbar burst fractures result from severe compressive axial loading [8, 16, 38]. They involve both the anterior and posterior walls of the vertebral body, or the anterior and middle columns according to Denis [8], and may cause retropulsion of bone fragments into the spinal canal, which results in neurological damage in about 50% of cases [4, 29]. The treatment of thoracolumbar burst fractures remains controversial. Many authors have advocated conservative management [4, 5, 22, 26, 27, 32, 40, 41], especially in stable fractures without neurological injury. Yet, the risks of delayed neurological deterioration or the development of painful kyphosis are not well defined. Denis *et al.* [9], reported 17% neurological complications and 17% severe kyphosis after nonoperative treatment. Twenty-two percent of their patients had late back pain and 11% failed to return to work.

To date, as appreciation of the complex biomechanics of spinal injuries has grown, early surgical treatment of burst fractures is increasingly favoured [1, 9, 19, 21, 24]. Advances in instrumentation technology, such as the development of rigid short-segmental anterior and posterior internal fixation devices as well as posterior distraction systems, have enabled surgical intervention with an acceptable complication rate. The goals of surgical treatment of thoracolumbar spinal fractures include: 1) decompression of the spinal canal and nerve roots to facilitate neurological 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 post-traumatic progressive deformity with neurological deficit, and 5) limiting the number of instrumented vertebral motion segments [1, 6, 21]. There is no general agreement on the choice of operative technique (anterior vs. posterior), with respect to these treatment goals.

Decompression of the spinal canal is achieved most successfully by a direct anterior approach [12, 17, 21, 28, 30, 34, 36], followed by stabilisation of the vertebral column by adequate rigid fixation. In a previous study [2], we found that a single rod and two screw

construct did not suffice and resulted in a high rate of loss of reduction. In such cases, stability can be improved by adding a posterior device at the same session, but this invokes an extensive surgical procedure. These problems may be circumvented by the use of internal fixators by which indirect decompression of the spinal canal can be performed by posterior distraction relying on kyphosis correction and ligamentotaxis [1, 6, 10, 37]. However, this method is reported to be less efficient in obtaining spinal cord decompression, which is often found to be incomplete [16, 18, 39].

At the Academic Medical Centre in Amsterdam, patients with thoracolumbar burst fractures have been treated by combined anterior-posterior surgery or by posterior instrumentation alone. In this study, we have compared the clinical outcome of these two surgical regimens, based on prospective data collection. Specifically, the following questions were addressed with regard to each type of surgery: 1) did the surgical approach affect neurological outcome? 2) was kyphosis correction maintained, and if not, did loss of correction relate to late-onset back pain?

Patients and Methods

Out of a consecutive series of 110 patients operated on for spinal injuries between May 1986 and October 1993, 54 patients with thoracolumbar burst fractures were identified. Follow-up data were available for 46 (85%) of these patients. The criteria for inclusion in this study were a positive radiological diagnosis of a burst fracture and surgical treatment being performed within 30 days after injury. Patients with flexion-distraction injuries with a burst component were excluded [23].

All patients were evaluated using antero-posterior and lateral radiographs, and by computerised tomography (CT) to assess the size of the spinal canal. The midsagittal diameters of the spinal canal at the injury level were compared with the average of the same diameter at one level proximal and one level distal to the injury, and expressed as a percentage of narrowing. In all cases severe narrowing of the spinal canal of more than 50% was demonstrated on CT. Fractures were categorised according to the Denis classification system [8]. Kyphotic deformity was assessed on lateral radiographs using the Cobb method. In particular, the amount of reduction initially and at late follow-up, and the occurrence of instrumentation failure were noted.

Neurological examination was performed at regular intervals pre- and postoperatively and graded using the Frankel scale. The level of pain and the functional outcome were assessed using the pain and employment scales as described in the Spine Fracture Study of the Scoliosis Research Society [17]. At late follow-up, neurological status, pain, and spinal deformity were re-assessed and compared with the presurgery status. Complications of treatment were also evaluated.

Surgical Technique

Anterior decompression and stabilisation combined with posterior stabilisation was performed in 27 patients (Group 1). Direct decompression of the spinal canal was performed by a subtotal corporectomy. Anterior stabilisation was performed using an iliac crest bone graft and osteosynthesis with the single-rod Slot-Zielke system [3], followed by additional posterior instrumentation and spondylodesis in the same session (Fig. 1). Posterior instrumentation was performed with the D.K.S. system of Zielke (rods and pedicle screw system) or with the Cottrel-Dubousset compression-rod system (rods and laminar hooks system).

The 19 patients in Group 2 underwent a posterior distraction instrumentation and stabilisation using the AO internal fixator [10]. Using a standard midline approach, the levels above and below the injured segment were exposed. Schanz screws were placed down the pedicles of the vertebrae on either side of the fracture. Reduction was carried out in three steps. First, dorsal vertebral body height was restored. Next, restoration of lordosis was obtained by pushing the cephalad and caudad stes of the Schanz screws together. The third phase was correction of the intervertebral distance by distraction. Intra-operative radiographs were taken to ensure that placement of the Schanz screws was correct and that adequate reduction of the fracture was achieved. Posterior fusion was subsequently performed in every patient.

The choice for either type of surgical approach was not randomised, but was decided by the surgeon based on availability of instrumentation and the presence of severe other organ injuries. All patients operated on before 1988 underwent combined anterior and posterior surgery. After 1988, patients with multiple injuries were preferrably operated on by a posterior only approach, unless major compression of the spinal canal by bone fragments existed in the presence of neurological impairment. In these cases, combined anterior-posterior surgery was performed. Postoperatively, all patients were mobilised in a light brace in neutral position for a period of 3 months.

Results

Preoperative Variables

All pre-operative data are presented in Tables 1 and 2. There were no significant differences between the two patient groups with respect to age, sex, cause of injury, or fracture classification (Denis). There were significantly more patients in Group 2 with other severe traumatic injuries, 58% vs. 22% in Group 1 ($P < 0.005$, Student T-test), reflecting the criteria for selection of the surgical approach as described above. The fracture level was at the thoracolumbar junction (T12-L1) in 19 patients in Group 1 (70%) and in 6 patients in Group 2 (32%). This difference was statistically significant ($P < 0.01$, Chi-square test). Neurological injury (Frankel Grade D or lower) was present in 10 patients in Group 1 (37%) and in 8 patients in Group 2 (42%). The degree of neurological dysfunction tended to be more severe in Group 1, with 4 patients having a Frankel Grade B lesion, but this difference was not statistically significant, due to the small number of patients. The loss of vertebral body height was somewhat greater in Group 1 (42% vs. 32%), but

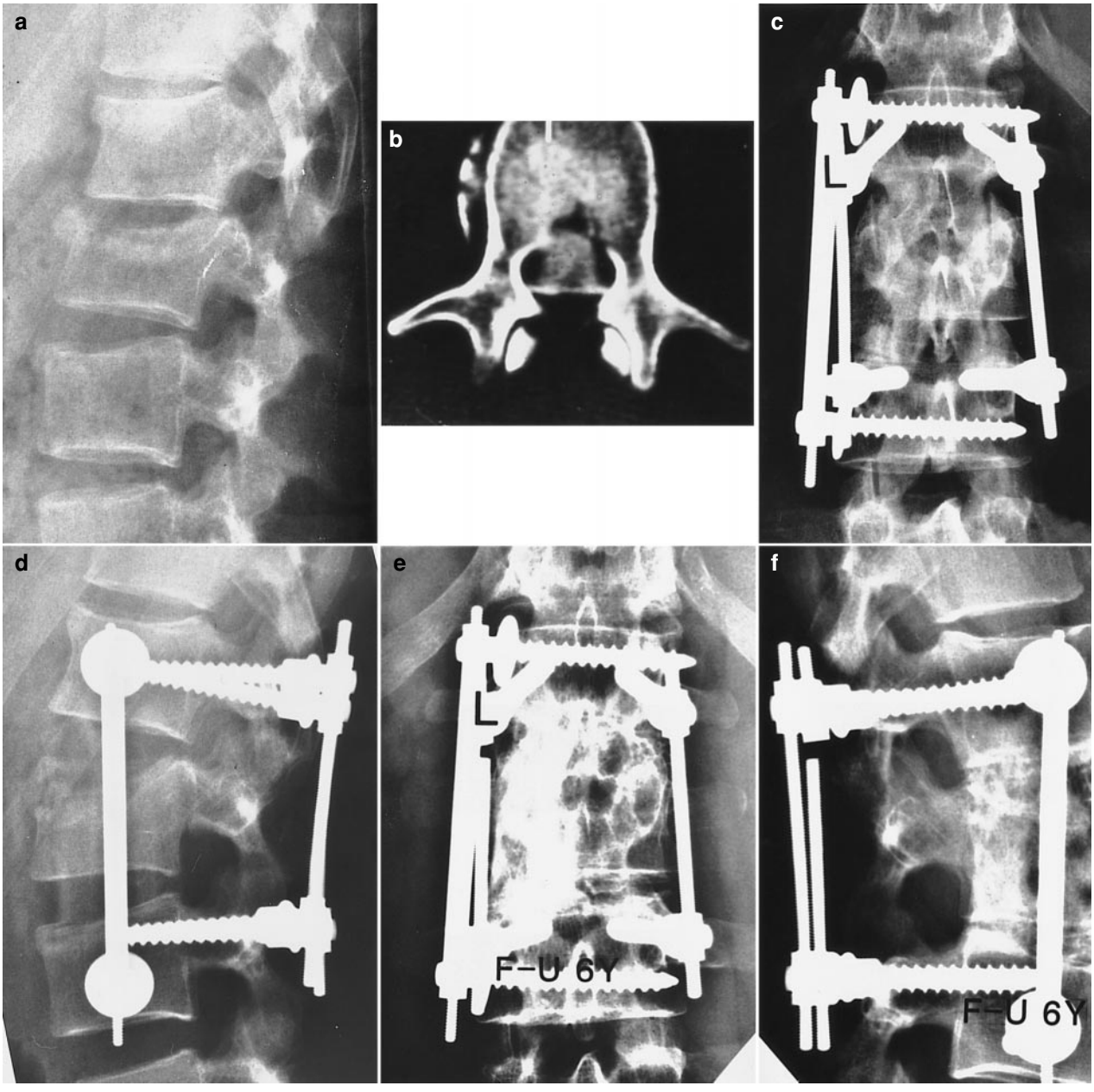

Fig. 1. (a) Lateral radiograph of a burst-fracture L2. (b) Pre-operative CT-scan showing severe canal encroachment. (c, d) Immediate post-operative antero-posterior and lateral radiographs showing anatomical reduction after anterior decompression, anterior and posterior stabilisation. (e, f) Antero-posterior and lateral radiographs 6 years after surgery showing solid fusion with minor loss of reduction, despite posterior rod breakage

this difference was not statistically significant. It should be noted though that, overall, there were only 5 patients with more than 50% body collapse.

Postoperative Kyphotic Correction and Back Pain

The postoperative parameters are summarised in Table 3. The loss of kyphotic correction between the early postoperative phase and at late follow-up was significantly greater in Group 2. Loss of reduction by more than 5° occurred in 13 patients (68%) in Group 2 vs. 2 patients (7%) in Group 1 ($P = 0.0013$, Wilcoxon Signed Rank test). Yet, as there was some over-correction immediately postoperative in Group 2 (kyphotic angle −4.1°), the kyphotic deformity in both groups at late follow-up was not different. In addition,

Table 1. *Patient Demographics and Pre-Operative Parameters*

Surgical technique	Group 1	Group 2
	anterior decompression and stabilization plus posterior stabilization	posterior distraction and stabilization with AO internal fixator
No. of patients	27	19
Age (mean ± S.D.)	26.8 ± 8.6	33.7 ± 13.1
Mean follow-up (years)	7.0	4.5
Male: female ratio	15:12	11:8
No. of patients with other severe injuries	6 (22%)	11 (58%)
Cause of injury		
fall	14 (52%)	11 (58%)
traffic accident	5 (18%)	3 (16%)
other	8 (30%)	5 (26%)
Neurological status (Frankel grade)		
A	0 (0%)	0 (0%)
B	4 (15%)	0 (0%)
C	3 (11%)	3 (16%)
D	3 (11%)	5 (26%)
E	17 (63%)	11 (58%)

Table 2. *Burst Fracture Level, Vertebral Body Collapse, and Fracture Classification*

Surgical technique	Group 1	Group 2
	anterior decompression and stabilization plus posterior stabilization	posterior distraction and stabilization with AO internal fixator
No. of patients	27	19
Level of injury		
T12	8	1
L1	11	5
L2	6	4
L3	2	5
L4	–	3
L5	–	1
Residual vertebral body height (%)		
mean ± S.D.	58 ± 11	68 ± 10
range	30–79	51–86
Fracture classification (Denis)		
A	7 (26%)	5 (26%)
B	12 (44%)	8 (42%)
C	0 (0%)	0 (0%)
D	8 (30%)	6 (32%)
E	0 (0%)	0 (0%)

there was no significant difference between groups with respect to pain at late follow-up with 83% of all patients being completely free of pain. Bony fusion eventually occurred in all patients.

Neurologic Outcome

The neurological outcome data are presented in Fig. 2. Neurological deterioration did not occur in any patient. Of the 27 patients in Group 1, 17 patients were neurologically intact (Frankel Grade E). Four patients presented with Frankel Grade B, three of whom improved to Grade D postoperatively, and one recovered completely (Grade E). Three patients were Frankel Grade C pre-operatively; all improved to Grade D. Three patients were Frankel Grade D and made full neurological recovery (Frankel E).

Of the 19 patients in Group 2, 11 had no neurologi-

Table 3. *Outcome of Surgical Treatment for Thoracolumbar Burst Fractures*

Surgery type	Group 1	Group 2
	combined anterior-posterior	posterior distraction and instrumentation
No. of patients	27	19
Bony union	27 (100%)	19 (100%)
Kyphotic angle (mean ± S.D.)		
early postoperative	1.2° ± 5.5°	−4.1° ± 9.9°
late follow-up	3.3° ± 7.7°	4.1° ± 12.4°
Loss of reduction > 5°	2 (7%)	13 (68%)*
Neurological improvement ≥ 1 Frankel grade	10/10	7/8
Recovery of bladder function	3/7	1/3
Pain level		
1. constant pain, requiring narcotics other than codeine	–	–
2. severe pain, daily codeine-type drugs	–	–
3. moderate pain, occasional codeine-type drugs	–	–
4. mild pain, requires aspirin-type drugs only	4 (15%)	4 (21%)
5. no pain, no medication	23 (85%)	15 (79%)
Complications	4 (15%)	5 (26%)
infection	1	1
instrumentation failure	1	4
misplaced pedicle screws	2	–

* $P = 0.0013$, Wilcoxon Signed Rank test.

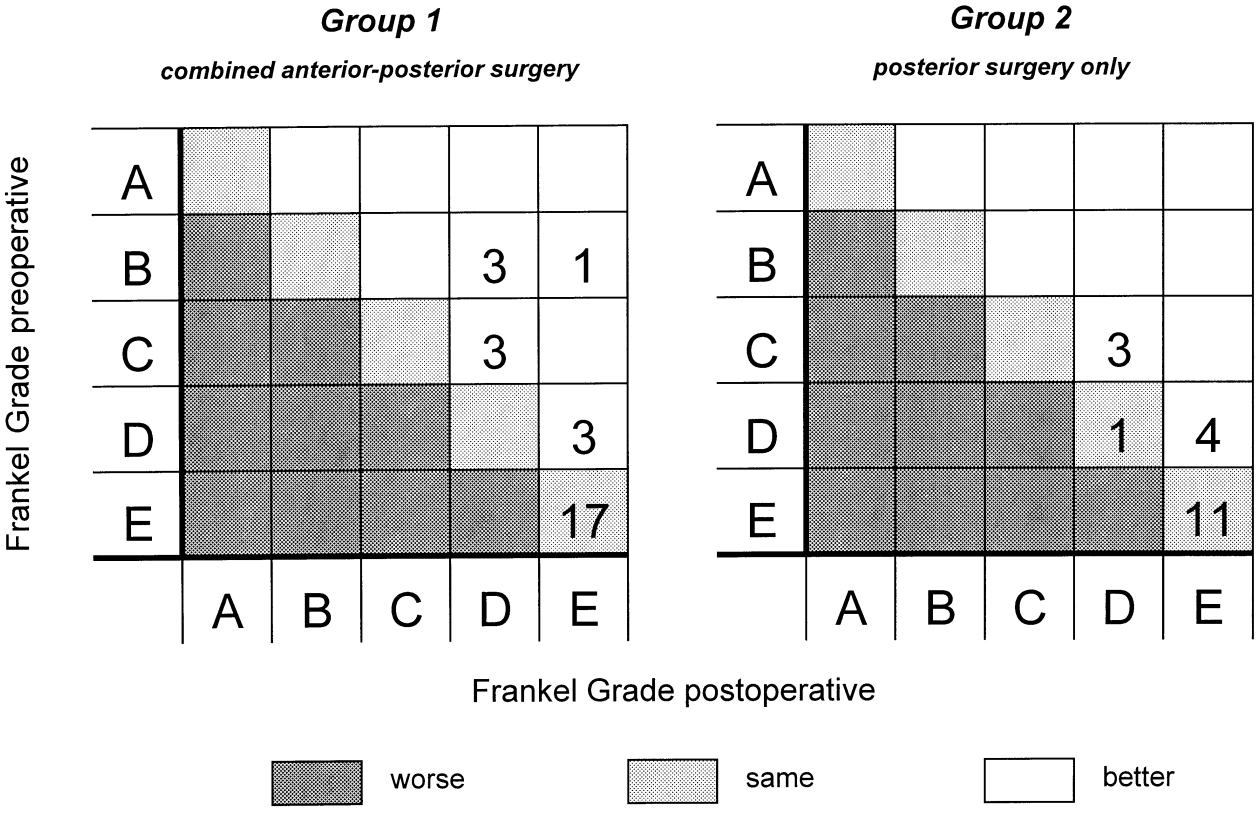

Fig. 2. Diagram showing change in Frankel grades in both treatment groups between the pre-operative status (vertical axis) and the status at late follow-up (horizontal axis)

cal symptoms at presentation (Frankel Grade E). Four of five patients who were Grade D on admission improved to Grade E; one patient remained unchanged. Three patients had a Grade C lesion; all improved to Grade D postoperatively. Thus, of the 18 patients in this study presenting with neurological deficit, all but one improved at least one Frankel Grade. Recovery of impaired bladder function was less common; it occurred in only 3 out of 7 patients in Group 1 with urinary incontinence, and in 1 out of 3 patients in Group 2. Retrograde ejaculation did not occur in any patient.

Complications

In both treatment groups there was one patient in whom a postoperative infection occurred. In both cases, it was necessary to remove the posterior device. Normal bony union was seen a few months afterwards, albeit with some loss of reduction. Breakage of osteosynthesis material was noted in one patient in Group 1 and in four patients in Group 2, without clinical consequences in each case. In Group 1, inadequate placement of a pedicle screw was observed in two patients. In both cases, normal bony fusion occurred, and no new neurological symptoms were encountered.

Discussion

Indication for Surgical Decompression in Burst Fractures

The management of thoracolumbar burst fractures remains controversial [15, 17, 31, 32]. The need for surgery in these cases is not always clear; conservative treatment has been reported to yield acceptable clinical results in neurologically intact patients [5, 26, 32, 40]. The rate of subsequent neurological deterioration appears to be low, while remodelling of the spinal canal due to absorption of retropulsed fragments occurs within one year in most cases [14, 26, 32]. The possible development of a late painful kyphosis after non-operative treatment, however, has been a matter of concern [9].

When a burst fracture is associated with neurological impairment, early surgical treatment may be indicated. Especially when neurological dysfunction is progressive in the presence of significant narrowing of the spinal canal, the need for surgical decompression will hardly be disputed. Although it has never been proven in a randomised study that early surgical intervention improves neurological outcome, anecdotal reports of dramatic improvement early after surgery are numerous, and empirical impression is that surgical clearance of the spinal canal will facilitate neurological recovery [17, 24, 28]. Yet, it remains to be determined if the long-term outcome in these cases differs from the natural history. Nonetheless, if more rapid improvement in the early phase does occur, this will have significant implications for early rehabilitation, because patients are able to achieve their maximum potential at a much faster pace.

Direct or Indirect Decompression

Many authors contend that anterior surgery results in a more complete and reliable decompression of the canal and offers superior mechanical stability [12, 18, 35, 36]. Thus, in cases where canal clearance is mandatory, direct decompression by an anterior or lateral approach is generally recommended [18, 20, 30]. The efficacy of indirect decompression by posterior reduction cannot be consistently predicted. The capability of posterior pedicle devices to enhance stability is well recognised [35], but the ability of posterior distraction instrumentation to reduce the displaced fragments is not fully established. Posterior reduction and stabilisation of thoracolumbar burst fractures is known to increase the spinal canal area by re-aligning the retropulsed bone fragments [10, 37, 39]. Canal clearance proved most effective when carried out in the first four days using the AO internal fixator. In fractures treated early and by experienced surgeons, there was little need of additional decompression [37]. Moreover, posterior surgery has the advantage of being faster, less expensive and causing less blood loss [7].

In the present study, neurological improvement occurred in all but one patient, regardless of the type of surgical decompression. It must be emphazised, though, that in most cases the degree of canal clearance was not verified by post-operative CT-scanning. However, data reported in the literature have shown that indirect decompression is usually effective [20, 37], and there is no reason to believe that our results would be different in this regard, especially since there were no increases in neurological deficits. It appears from our data that the technique of decompression (direct or indirect) does not influence the rate of neurological improvement. However, these results should be in-

terpreted with some caution, as treatment was not randomised in this study. The fact that there were more injuries at the cord-conus level in Group 1 and more at the cauda equina level in Group 2, as well as the fact that the loss of vertebral body height was somewhat greater in Group 1, alludes to the possibility that the injuries in Group 1 were more severe to begin with, although the difference in pre-operative Frankel Grades between both groups did not reach statistical significance.

Our results are compatible with other studies comparing direct and indirect decompression. Esses and coworkers [12] reported a prospective randomised study comparing anterior decompression and instrumentation with posterior distraction using pedicle instrumentation in 40 patients. There were no significant differences with respect to Frankel Grade improvement or kyphosis correction. Gertzbein [17] reported prospective data demonstrating that anterior surgery was more effective than posterior surgery in restoring bladder continence but not in improving Frankel Grade. Our data showed no difference between Group 1 and Group 2 with respect to bladder function. Danisa *et al.* [7] retrospectively studied 49 patients with acute unstable thoracolumbar burst fractures who underwent either anterior, posterior, or combined anterior-posterior surgery. These authors concluded that anterior and posterior surgery were equally effective, but considered combined procedures inferior treatment because of the longer operative time and higher morbidity.

Fixation Technique and Spinal Deformities

Besides clearance of the spinal canal and cord decompression, other goals of surgical treatment include stabilisation and correction of kyphotic deformity to permit early mobilisation and rehabilitation. The results of surgery in this respect should also be considered. There are many stabilisation-devices; all have their advantages and disadvantages. Anterior systems, consisting of one solitary rod, like the Slot-Zielke device show some weakness in forward-bending, loading and torsional stability. Other types of rigid anterior fixation such as double rods or plate systems may not show these effects, but may still lead to loss of kyphosis correction: in clinical series of surgical treatment for spinal burst fractures, corporectomy and stutgrafting often led to some collapse of the graft and residual kyphosis due to posterior instability [2, 11, 13]. Stability in these cases can be improved by adding a posterior device at the same session, to restore the tension-band effect. In engineering terms, evaluations of the load-sharing concept demonstrate that complex segmental instabilities with distinct anterior defects should be treated with a combined anterior-posterior construct [13]. When the anterior defected column is adequately supported by a graft or device, the loads on the posterior construct are decreased significantly by at least 70% to allow for smaller semi-rigid and thus more compliant implant constructs [13, 33].

These laboratory investigations were confirmed by this clinical study. Although bony union was achieved in all patients, in Group 2 a high rate (68%) of loss of reduction of more than 5° was observed, versus only 7% in Group 1. On the other hand, the mean kyphotic angle in Group 2 was only 4° due to a relative over-correction in the acute stage. This loss of reduction in Group 2 was not associated with higher degrees of back pain. This finding concurs with the results of the Scoliosis Research Society Multicenter spine fracture study [17], showing that significant back pain and disability was associated with kyphosis exceeding 30° at 2 year follow-up.

Conclusion

Neurological outcome in patients treated by a combined anterior and posterior approach did not differ from that in patients treated by posterior distraction and stabilisation using pedicle instrumentation, although decompression of the spinal canal may be more complete with a direct anterior approach than with posterior distraction. In this study, the combined anterior-posterior approach yielded the best results in terms of long-term maintenance of kyphosis correction. Posterior distraction and short-segment stabilisation with the AO-internal fixator was followed by some loss of reduction, but the long-term kyphosis angle was acceptable (4°) and was not associated with a higher incidence of pain. Therefore, indirect decompression of the spinal canal by posterior distraction and short-segment stabilisation with AO-internal fixator may be sufficient treatment for the majority of unstable thoracolumbar burst fractures. Only in cases where direct clearance of the spinal canal is deemed necessary, an anterior approach is preferrable. It should be noted that when rigid types of anterior instrumentation such as double-rod systems or plates are used, additional posterior stabilisation may not be

necessary [24, 25, 28], but our data are inconclusive in this respect.

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