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ORIGINAL STUDY

Transpedicular bone grafting as a supplement to posterior pedicle screw instrumentation in thoracolumbar burst fractures

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The objective of the present study was to investigate whether transpedicular bone grafting as a supplement to posterior pedicle screw fixation in thoracolumbar fractures results in a stable reconstruction of the anterior column, that allows healing of the fracture without loss of correction.

Posterior instrumentation using an internal fixator is a standard procedure for stabilizing the injured thoracolumbar spine. Transpedicular bone grafting was first described by Daniaux in 1986 to achieve intrabody fusion. Pedicle screw fixation with additional transpedicular fusion has remained controversial because of inconsistent reports.

A retrospective single surgeon cohort study was performed. Between October 2001 and May 2007, 30 consecutive patients with 31 acute traumatic burst fractures of the thoracolumbar spine (D12-L5) were treated operatively. The mean age of the patients was 45.7 years (range : 19-78). There were 23 men and 7 women. Nineteen thoracolumbar fractures were sustained in falls from a height ; the other fractures were the result of motor vehicle accidents.

The vertebrae most often involved were L1 in 13 patients and L2 in 8 patients. According to the Magerl classification, 25 patients sustained Type A1, 4 Type A2 and 2 Type A3 fractures.

The mean time from injury to surgery was 6 days (range 2-14 days).

Two postoperative complications were observed : one superficial and one deep infection.

Mean Cobb's angle improved from +7.16° (SD 12.44) preoperatively to -5.48° (SD 11.44) immediately after operation, with a mean loss of correction of 1.00° (SD 3.04) at two years.

Reconstruction of the anterior column is important to prevent loss of correction.

In our experience, the use of transpedicular bone grafting has efficiently restored the anterior column and has preserved the post-operative correction of kyphosis until healing of the fracture.

Keywords : thoracolumbar fractures ; transpedicular bone grafting ; burst.

INTRODUCTION

The term "burst fracture" was first coined by Holdsworth *(12)* to characterize 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 *(8)* 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

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Fig. 1. — Burst fracture, preoperative radiograph (lateral view). The radiologic hallmark of the burst fracture : a compression fracture of the anterior and middle vertebral columns, which causes retropulsion of a posterior vertebral body fragment into the spinal canal.

vertebral body fragment into the spinal canal, which is the radiographic hallmark of the burst fracture (*3,4,20,21,32*) (fig 1).

Burst fractures represent about 10-20% of all spinal fractures (*16*) and are often seen in young patients (*8*). Their treatment remains controversial. Although a large number of papers have been published describing techniques for the reduction and stabilization of these fractures, as well as conservative treatment, no consensus exists about the ideal treatment (*29*). Posterior instrumentation, using an internal fixator, is a standard procedure for stabilizing the injured thoracolumbar spine. Nevertheless there is controversy about the possibility for this method to maintain the correction in the sagittal plane (*14,30*). Recurrence of kyphosis with or without material failure is reportedly not uncommon. Some authors believe that recurrent kyphosis is mainly due to the collapse of the disc space after implant removal (*17,30,34*). Other authors concluded that transpedicular bone grafting of the fractured vertebra in combination with posterior instrumentation is not the optimal method to restore an anterior column with normal load-bearing capacity (*15*).

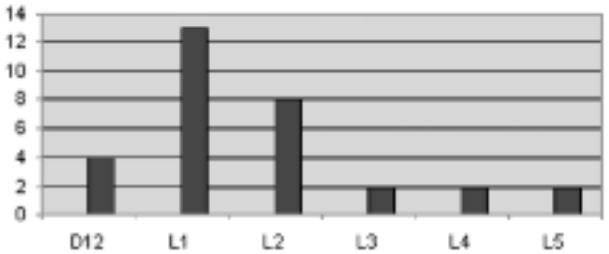

Fig. 2. — Histogram of vertebral fracture levels

MATERIALS AND METHODS

Thirty consecutive patients with 31 thoracolumbar burst fractures underwent surgical treatment and were retrospectively evaluated clinically and radiographically by an independent investigator who was not involved in the primary treatment. Patient ages ranged from 19 to 78 years (mean 45.7 years). Twenty-three patients were males and seven were females. Trauma was caused by a fall from a height in 19 patients, and by a road traffic accident in 11. The fracture was located at the D12 level in four patients, at L1 in thirteen, at L2 in eight, L3 in two, L4 in two and L5 in two (fig 2).

According to the classification of Magerl *et al* (*18*) there were twenty six type A.1 burst fractures, six type A.2 and two type A.3 burst fractures. Neurologic deficit was assessed using the scale of Frankel *et al* (*10*) with all patients being classified as Frankel E. The kyphosis was measured on a lateral X-ray view from the superior endplate of the vertebral body one level above the injured vertebral body to the inferior endplate of the vertebral body one level below (Cobb technique) (*9*). One single orthopaedic surgeon did the surgery on all patients. All patients were submitted to posterolateral arthrodesis and posterior fixation with an internal fixator (USS, Synthes). The stabilization was augmented by an intrabody fusion, as described by Daniaux in 1986 (*5*). A small hole was made through the pedicle of the fractured vertebra. Through this hole the Daniaux funnel was put in place. A combination of autologous cancellous iliac bone grafts and allografts was used to augment the vertebra. Special attention was given to this part of the procedure. The grafts were impacted with a small hammer and the desimpaction of the vertebra was followed fluoroscopically during this part of the procedure. The grafting was stopped when the normal anatomical configuration of the vertebra was restored ; even a slight 'overstuffing' of the vertebra with grafts was allowed (fig 3 & 4).

Fig. 3. — Transpedicular bone grafting. After reduction and transpedicular bone grafting we notice a stable reconstruction.

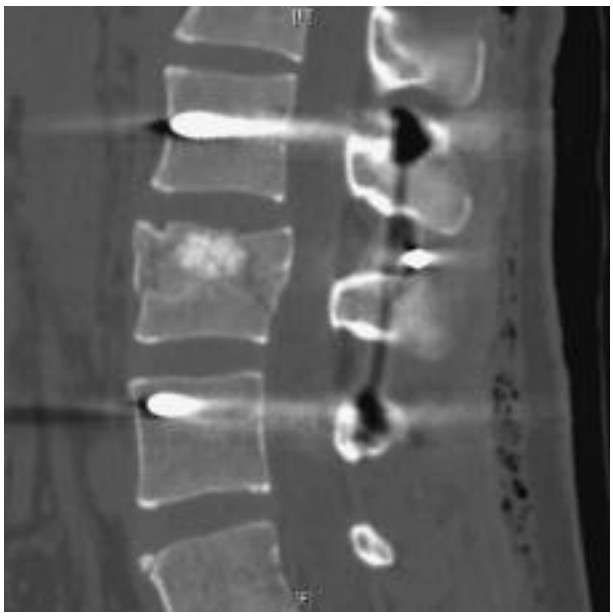

Fig. 4. — Transpedicular bone grafting. CT scan after transpedicular bone grafting. Note the bone grafts in the centre of the fractured vertebra. The grafts fill the hole that was created after reduction, preventing collapse.

The mean time interval between injury and surgery was 6 days (range : 2-14 days). During the postoperative period, walking and rehabilitation were started based on the pain symptoms and associated injuries of the patients. During the post-operative period a brace supported the patients for a period of 12 weeks during 12 hours each day. None of the implants were removed before the end of the study.

Pre-operative Cobb's angles were noted and compared with immediate post operative angles, after reconstruction. At six months and after two years, the loss of reconstruction was noted. The parameters of radiographic evaluation were analyzed using Wilcoxon's signed-ranked test. Individual values are given in table I, with positive values implying kyphosis and negative values denoting lordosis (table I).

RESULTS

The patients were followed for a period of 24 months after surgery.

The angle representing the regional sagittal alignment improved from a mean value of 7.16° kyphosis (SD 12.44) before surgery to 5.48° lordosis (SD 11.44) after surgery (fig 5). The values observed during the immediate postoperative period differed significantly from the preoperative values ($p < 0.00002$, Wilcoxon) and from the late post-operative values ($p < 0.00005$, Wilcoxon). The average correction loss in local kyphosis between the immediate postoperative period and the latest follow-up was 1.00°, which was not significant ($p = 0.094$, Wilcoxon).

The complications observed in the 30 patients studied were one superficial and one deep infection. Both resolved with intravenous antibiotics administration and debridement.

DISCUSSION

Evaluation and comparison of thoracolumbar fractures should consider specific types of fractures with similar morpho-pathological characteristics. Burst fractures vary widely in morphology, so it is difficult to obtain a homogeneous group for study and comparison (*24,29*).

Different treatments have been proposed for thoracolumbar burst fractures, with controversial results

Table I. — Patients' characteristics and changes in radiographic parameters over time.
(negative values of Cobb's angle denote lordosis)

Patient #	Age (years)	Gender	Level	Cobb preop (degrees)	Cobb postop (degrees)	Difference (degrees)	Cobb 2 years (degrees)	Change from postop (degrees)
1	51	M	L1	20	-6	26	-6	0
2	40	M	L3	8	-12	20	-10	-2
3	72	M	L1	6	-2	8	-2	0
4	23	M	L2	10	-10	20	-10	0
5	53	M	L1	6	-4	10	-4	0
6	20	M	L2	-16	-13	3	-13	0
7	24	M	L4	-24	-22	2	-22	0
8	19	F	L4	18	-28	46	-22	-6
9	45	M	L2	6	-2	8	-2	0
10	45	M	L1	-8	-2	6	-2	0
11	78	M	L2	8	-8	16	-6	-2
12	67	M	L1	5	-2	7	-5	3
13	42	M	L1	8	2	6	2	0
14	57	M	L5	-26	-30	4	-30	0
15	47	M	L1	6	-6	12	0	-6
16	67	M	L1	10	-12	22	-4	-8
17	58	M	L1	13	-2	15	-9	7
18	47	M	L2	4	-4	8	-2	-2
19	27	F	L2	14	-6	20	-6	0
20	20	F	L3	8	-14	22	-14	0
21	30	F	L1	16	-2	18	-2	0
22	62	F	D12	10	-9	19	-10	1
23	61	F	L1	25	-9	34	-12	3
			L5	31	24	7	30	-6
24	54	M	D12	16	-8	24	-6	-2
25	37	F	L1	15	18	-3	19	-1
26	35	M	D12	4	-12	16	-8	-4
27	25	M	D12	18	-2	20	-2	0
28	54	M	L1	3	-5	8	-5	0
29	50	M	L2	-4	-2	2	-2	0
30	64	M	L2	12	20	-8	26	-6

reported by different authors (*1,7,27,29,34*). It remains unclear if conservative or operative treatment is more effective (*28*). Radiologic, clinical and functional parameters are used in the debate about the ideal method for the treatment of these fractures.

Regarding the measurement of angulation of the fractured vertebral segment in the sagittal plane, loss of correction of 10° has been observed with the various treatment methods used such as conservative treatment, posterior fixation, posterior fixation with a transpedicular graft, anterior fixation and combined posterior fixation and anterior fusion (*1,7, 14,16,17,29*). This has led several authors to conclude that no treatment is able to restore the morphology of the vertebral segment to normal physiological levels for thoracolumbar spine fractures (*29*).

Mumford *et al* (*22*) found good and excellent results in 66% of nonoperatively managed patients without neurologic deficit. The mean kyphotic deformity at follow-up evaluation increased by 1° to 7° after nonoperative management, as compared with the initial angulation (*22*). Similar results were noted in other studies of nonoperative management (*2,6,25,26*).

Wood *et al* (*33*) compared two similar groups, one treated operatively, the other nonoperatively. In the

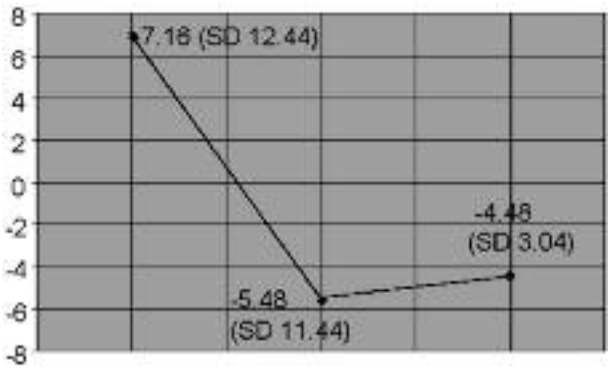

Fig. 5. — Cobbs' angle (in degrees) preoperatively, immediately after operation and at latest follow-up.

operative group, the average fracture kyphosis was 10.1° on admission and 13° at final follow-up evaluation. In the nonoperative group the average kyphosis was 11.3° on admission and 13.8° at final follow-up examination after treatment. So they concluded that operative treatment of patients with a stable thoracolumbar burst fracture offers no major long-term advantage compared with nonoperative treatment. The current study group involved 31 injuries involving the anterior column. In contrast to the results of nonoperative treatment, the mean kyphotic deformity significantly improved by 12.65° with 1.00° loss of correction at 24 months follow-up.

The mean loss of correction in our series was also similar to those of the series of anterior decompression and stabilization with the Kaneda device (1°) (*13*) and Z-plate (2°) (*19*). More complications were noted in the anterior stabilisation : Kaneda reported non union in 7%, corrected with posterior spinal instrumentation, breakage of the Kaneda device in 6% and sympathectomy effect on the ipsilateral lower extremity in 10% (*13*).

Olerud *et al* (*23*) described a group of twenty patients with thoracolumbar burst fractures, treated with transpedicular cancellous bone grafting and internal fixation similar to our technique. They noted a loss of correction of 4°.

Verlaan *et al* (*29*) performed a systematic review of the literature on thoracolumbar fractures. They compared two groups, one group with 750 patients who had undergone additional transpedicular bone grafting and a group of 924 patients without bone grafting ; all patients had undergone posterior stabilisation. Both groups were comparable in terms of follow-up, gender, age, type of fracture and fracture level. In the group with transpedicular bone grafting they noted a loss of correction of 8.9°, versus 5.7° in the other group. The conclusion was that transpedicular bone grafting does not maintain the correction. The outcome in terms of pain was comparable.

Knop *et al* (*15*) retrospectively reviewed 50 patients treated operatively : all had posterior stabilisation ; 36 patients had interbody fusion via transpedicular bone grafting of the involved segment, and 14 patients had no interbody fusion. A significantly better correction was found in the patients who had not received transpedicular bone grafting : 11.5° as compared with 3.8° in the transpedicular bone grafting group. A comparable loss of correction was noted over a period of 6 months and after hardware removal. Therefore, they also concluded that the addition of transpedicular cancellous bone grafting did not decrease the loss of correction.

Wang *et al* (*31*) treated seventy patients by short-segment pedicle screw fixation and the patients were randomly divided into two groups. Fractures in group A (n = 20) were reinforced with transpedicular morselized bone grafting, while patients in group B (n = 50) did not receive the morselized bone grafting for bone fusion. The two groups were compared in terms of kyphotic deformity after the treatment. The kyphosis correction achieved in group A was 6.4°, in group B 5.4°. At the end of follow-up, kyphosis correction was maintained in group A but was lost in group B. So they also concluded that reinforcement of short-segment pedicle fixation with morselized bone grafting for the treatment of patients with thoracolumbar vertebrae fracture could achieve and maintain kyphosis correction.

We have shown that in our series, using the technique of impaction bone grafting in combination with posterior pedicle screw instrumentation, a good restoration of the sagittal curve is possible without loss of correction during the healing of the

fracture. In our opinion the technique of grafting has a great influence on the postoperative results during follow-up. In literature we did not find a clear and detailed description of how the grafting was performed, neither about the type and volume of grafts that was used. The prevalence of recurrence of the kyphotic deformity after removal of the implant, as mentioned in some studies, is due to changes in de disc space and not in the vertebral body (*34*). In the current study, hardware was not removed, and there is no intention to remove it unless this is necessary. Removal of the hardware will be necessary in case of pain due to the hardware. We expect that in our series the correction would diminish after removal of the hardware. We will keep this in mind in our further follow-up and perhaps we can investigate this point of interest in the future.

CONCLUSION

In this cohort of 30 patients with 31 thoracolumbar fractures, correction by posterior screw fixation and transpedicular bone impaction grafting has provided good radiographic results concerning correction of the sagittal curve. There was minimal loss of correction and a very low complication rate. The technique for grafting markedly influences the final outcome.

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