# Recurrent kyphosis after posterior stabilization of thoracolumbar fractures

## 24 cases treated with a Dick internal fixator followed for 1.5–4 years

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24 patients with Th12–L1 fractures treated with a Dick internal fixator were analyzed to assess predictors of poor outcome. 4 patients had fixation without bone transplantation, 20 patients had a posterior fusion, and 12 of them had additional transpedicular spongioplasty. There were fractures of the transpedicular screws in 4 and screw migration in 2 cases. The increase in the local kyphosis angle was greater than the increase in the anterior compression angle and this did not correlate with spongioplasty or fusion. Fixation failure was in all cases related to a disproportionate increase in the local kyphosis angle. There was no difference between the patients with transpedicular spongioplasty and posterior fusion and the other patients with respect to results and complications. Bony collapse was not the major cause of failure and consequently there was no measurable contribution of transpedicular spongioplasty. We found that the Dick internal fixator for unstable fractures was associated with a higher complication rate than earlier reported.

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Pedicle screw instrumentation makes it possible to reduce thoracolumbar burst fractures over a short segment. This seems to be biomechanically advantageous (Aebi 1987, Dick 1987, Broom and Jacobs 1989, Esses 1989, An et al. 1991, Ebelke et al. 1991, Lindsey and Dick 1991, Bednar 1992, Benson et al. 1992). However, the results of a short-segment posterior stabilization are not always good. Recurrent kyphosis with or without material failure has been reported (Matsuzaki et al. 1990, McAfee et al. 1991, West et al. 1991, McLain et al. 1993, Sasso and Cotler 1993, McCormack et al. 1994). Determination of factors which predict the failure of posterior stabilization would be helpful in determining which patients need a more extensive procedure. We have therefore retrospectively analyzed a group of 24 patients with burst fractures at the thoracolumbar junction, managed with a Dick internal fixator.

## Patients and methods

24 patients with a traumatic fracture of the thoracolumbar junction of Th12 or L1 managed with a Dick internal fixator between 1986 and 1991 in 3 University Hospitals (Leiden, Utrecht and Rotterdam) were studied (Table 1). 1 patient (case 10) had also a burst type L4 fracture, which was treated with a second internal fixator, and another patient (case 15) had an L3 compression fracture which required no additional treatment. There were 12 women and 12 men with 7 Th12 and 17 L1 fractures. The average age of female patients was 37 (15–67) and of male patients 26 (17–43) years. Pre-operative plain radiographs and CT-scans were available for all patients. The indications for operation accorded with the Denis et al. (1984) classification. 2 fractures were classified as having instability of first degree (cases 1 and 5) and 22 of second degree. 12 fractures were unstable according to the classification of Louis (1977). In 10 patients with complete or partial neurological impairment, an intracanal posterolateral reduction of compressing fragments was performed through a partial laminectomy. All of the patients except 6 were operated on within 1 week of trauma. In cases 2, 3, 18, and 22, there was a delay because of cerebral lesions or cardiopulmonary instability and cases 1 and 14 were referred to us later. Reduction

**Table 1. General data concerning patients**

| A | B | C | D | E | F | G | H/a | H/b | H/c | I/a | I/b | I/c | J |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 32 | 2 | 4 | 1 | 0.5 | 0 | 16 | 12 | 18 | 22 | 21 | 40 | 3 |
| 2 | 48 | 1 | 2 | 4 | 2 | 2 | 30 | 7 | 17 | 34 | 7 | 32 | 1 |
| 3 | 19 | 2 | 2 | 4 | 2 | 2 | 13 | 15 | 13 | 9 | 10 | 14 | 0 |
| 4 | 21 | 1 | 1 | 5 | 2 | 0 | 23 | 18 | 17 | 23 | 21 | 25 | 1 |
| 5 | 33 | 2 | 4 | 2 | 0.5 | 0 | 34 | 10 | 14 | 30 | 5 | 14 | 0 |
| 6 | 52 | 1 | 1 | 3 | 1.5 | 1 | 20 | 11 | 9 | 13 | 5 | 7 | 0 |
| 7 | 22 | 2 | 4 | 4 | 2.5 | 3 | 22 | 15 | 18 | 22 | 1 | 9 | 0 |
| 8 | 28 | 2 | 4 | 4 | 2.5 | 3 | 13 | 4 | 6 | 14 | 10 | 8 | 1 |
| 9 | 41 | 2 | 4 | 4 | 2.5 | 3 | 14 | 6 | 6 | 14 | 3 | 2 | 0 |
| 10 | 39 | 1 | 3 | 4 | 2.25 | 4 | 19 | 10 | 12 | 18 | 2 | 28 | 2 |
| 11 | 50 | 1 | 2 | 5 | 2.25 | 0 | 8 | 0 | 1 | 13 | 1 | 12 | 0 |
| 12 | 19 | 2 | 2 | 4 | 1.5 | 0 | 14 | 9 | 11 | 8 | 4 | 24 | 1 |
| 13 | 17 | 2 | 1 | 4 | 2.25 | 3 | 28 | 28 | 27 | 30 | 26 | 30 | 1 |
| 14 | 67 | 1 | 2 | 3 | 1.5 | 0 | 4 | 5 | 21 | 8 | 6 | 31 | 1 |
| 15 | 21 | 2 | 2 | 4 | 1.5 | 2 | 30 | 22 | 20 | 31 | 18 | 32 | 1 |
| 16 | 19 | 1 | 3 | 4 | 2.5 | 0 | 27 | 10 | 22 | 15 | 10 | 20 | 1 |
| 17 | 15 | 1 | 3 | 4 | 1.5 | 4 | 28 | 14 | 16 | 28 | 7 | 20 | 1 |
| 18 | 43 | 1 | 2 | 4 | 1.5 | 4 | 18 | 17 | 20 | 23 | 18 | 33 | 1 |
| 19 | 44 | 1 | 2 | 4 | 2 | 0 | 28 | 8 | 13 | 19 | 4 | 13 | 1 |
| 20 | 20 | 2 | 2 | 4 | 1.5 | 0 | 15 | 12 | 12 | 4 | 10 | 20 | 1 |
| 21 | 27 | 1 | 3 | 3 | 2 | 4 | 32 | 30 | 34 | 20 | 12 | 40 | 1 |
| 22 | 43 | 2 | 3 | 4 | 1.5 | 4 | 26 | 8 | 9 | 9 | 9 | 13 | 2 |
| 23 | 18 | 1 | 2 | 4 | 2 | 3 | 25 | 8 | 10 | 21 | 5 | 2 | 0 |
| 24 | 17 | 2 | 4 | 4 | 2 | 0 | 24 | 17 | 17 | 17 | 14 | 20 | 0 |

A Case
B Age
C Sex
  1 female
  2 male
D Cause
  1 road accident
  2 fall
  3 attempted suicide
  4 industrial accident
E Type Denis
  1 1A
  2 1B
  3 2A
  4 2B
  5 2E
F Stability based on the Louis points of instability (0–3).
  Unstable if ≥ 2
G Neurology
  0 no injury
  1 cerebral commotion
  2 cerebral contusion
  3 paraplegia
  4 conus syndrome
H Anterior compression angle (W)
  /a preoperative
  /b postoperative
  /c last measured
I Kyphosis angle (K)
  /a preoperative
  /b postoperative
  /c last measured
J Patient satisfaction
  0 excellent
  1 good
  2 fair
  3 poor

technique, as described by Dick (1987), was used in all the cases. A posterior spondylodesis between 3 vertebra was performed, except in cases 14, 17, 19, and 20. In 12 patients (cases 1–12) additional transpedicular autologous spongiosaplasty of the fractured vertebra was performed (Daniaux 1986, Dick 1987). Within 2 weeks after the operation, patients were allowed to stand or sit in a molded thoracolumbar orthosis or a brace which was worn for about 3 months. In 5 patients with complete and non-resolving paraplegia, the fixator was not removed. In the others, the fixator was removed after a minimum of 1 year.

At 35 (18–48) months follow-up, all the patients were examined by persons not involved in the treatment. Standing or sitting AP and lateral radiographs were obtained. Patient satisfaction was evaluated during an interview. All radiographs and CTs were reviewed. Anterior compression angle (wedge W) of the fractured vertebra and local kyphosis (K) angles between the vertebrae above and below the fracture were measured according to Denis et al. (1984). Fractures were also classified according to Louis (1977). Posterior cortex height (PCH) of the vertebral body as a percentage of that of the caudal vertebra was measured as described by Aebi (1987). Descriptive statistics and t-tests were performed using SPSS/PC+, version 5.0.1. The two-sample t-test was used to test differences between groups.

Table 2. Statistical analysis of the evolution of W- and K-angles in group A (additional transpedicular spongioplasty) and group B (no transpedicular spongioplasty)

| | Group A | | Group B | | 95% confidence interval |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| A | 34 | 12 | 29 | 16 | -8–17 |
| B | 19 | 8 | 24 | 8 | -12–3 |
| C | 18 | 8 | 19 | 9 | -9–7 |
| D | 9 | 7 | 8.8 | 8 | -7–7 |
| E | 11 | 10 | 7.2 | 8 | -5–12 |
| F | 2 | 5 | 3.5 | 5 | -6–3 |
| G | 10 | 10 | 11 | 9 | -10–8 |

A Age
B W-angle preoperatively
C K-angle preoperatively
D Correction of W-angle (difference between post- and preoperative values)
E Correction of K-angle (difference between post- and preoperative values)
F Loss of correction of W-angle (difference between last measured and postoperative values)
G Loss of correction of K-angle (difference between last measured and postoperative values)

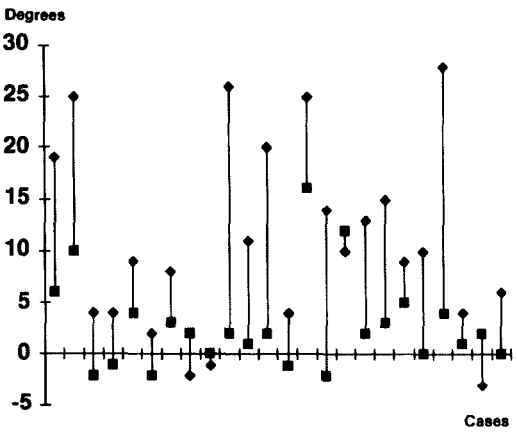


Figure 1. Change in K- and W- angles ( difference between the last measured and direct post-operative values). ◆ K, ■ W

## Results

There was one deep infection (case 3) and removal of the implant was necessary 5 months after the operation. This patient was further managed with a cast and the infection resolved. No neurological complications were associated with the operations. In 4 cases (2, 10, 15, and 21), some of the transpedicular screws fractured. In case 21, both cranial screws were broken within 6 weeks after the operation. The fixator was replaced, but the new screws fractured after 6 months. In cases 1 and 12, screw migration was observed without material failure. In 12 cases (1, 2, 10–12, 14–18, 20, and 21), we observed a 10° or more increase in the K-angle during the follow-up period. In only 3 of them was there an accompanying 10° or more increase in the W-angle (cases 2, 14, and 16). Loss of PCH was observed in cases 2 and 14. 1 patient found the result poor and two patients considered it fairly good. The rest were satisfied.

We compared patients with (group A: cases 1–12) and without (group B: cases 13–24) a transpedicular spongioplasty (Table 2). For none of the preoperative variables there was a statistically significant difference between the 2 groups. We consider the possible differences, as indicated by the confidence intervals, too small to invalidate our comparison of the results.

In group A, the preoperative mean W- and K-angles were each 19° and postoperatively these were reduced to 10° and 8°, respectively. The PCH was corrected from a mean of 84 to 95 percent and remained the same during the follow-up in all, except case 2 who also had an increase of 10° in the W-angle. In 5 cases (1, 2, 10, 11, and 12) there was a 10° or more increase in the K-angles, 4 of which had complications (cases 1 and 12 had screw migration and cases 2 and 10 screw fracture).

In group B, the pre-operative mean W-angle was 24° and the K-angle 19°, and post-operatively these were reduced to 15° and 12°, respectively. The PCH was reduced from a mean of 87 to 93 percent, and remained the same at a mean of 90 percent, except in case 14. A 10° or more increase in the W-angle was observed in 2 cases (14 and 16). 7 cases (14–18, 20, and 21) showed a progression of the K-angle of 10° or more and 2 of them had complications (screw fracture in cases 15 and 21).

The difference in the degree of the K-angle or W-angle reduction between the two groups was not significant (Table 2). The difference in the increase of the K-angle or W-angle during the follow-up was not significant either. In the whole group there was no correlation between the instability scores, according to Denis or Louis (p 0.8 and p 0.6), or the amount of reduction in the K- or W-angle (p 0.9 and p 0.1, respectively) with the final increase in K- or W-angle. There was no significant difference in subjective evaluation between the 2 groups (p 0.2). The difference in increase in the W-angle or the K-angle between the group of 10 patients who underwent a decompression and the other patients was not significant (p 0.3 and p 0.5, respectively).

For the whole group, the average increase in the K-angle was higher than that in the W-angle (Figure 1). This difference was highly significant (one-tailed t-test with $H_0$ no difference, p 0.001).

Concerning the 3 patients with a 10° or more increase in the W-angle, case 14 was a 67-year-old woman with osteoporotic bone and case 16 was a 19-year-old woman with primary hyperprolactinemia. The third patient (case 2) was a 48-year-old woman who had been lost to follow-up until she was called back for this study 2 years after the operation. 2 of these patients (cases 2 and 14) were also the only ones in whom a loss of PCH was observed.

## Discussion

Extent of bone comminution has long been regarded as a major determinant of the success of posterior stabilization in burst fractures. Louis (1977) based his classification on the stability of bony structures. Recently, there was a new attempt to classify bone comminution with emphasis on the load-sharing characteristics of the fractured vertebral body (McCormack et al. 1994). However, as shown by the experimental study by Lin et al. (1993), the bony lesion is responsible for less than half of the post-traumatic instability, the reminder being caused by non-osseous structures, including the intervertebral discs. As one might expect a rapid union of the cancellous bone after a comminuted fracture the discs may be the main cause of chronic instability (Lin et al. 1993). In our group there was no correlation between the Louis score and the final increase in kyphosis. Transpedicular spongiosaplasty is meant to strengthen the broken vertebral body (Daniaux 1986). However, in our study we found no effect of the spongioplasty. One explanation may be the amount of correction of the W-angle in this series, which seems to be less than that reported in some studies (Aebi 1987, Dick 1987, Esses 1989, Lindsey and Dick 1991). The most remarkable finding in our series was the difference between the evolution of the K- and W-angles. The W-angles were stable during the follow-up, except in 3 cases, 2 of whom had a hormonal predisposition to osteoporosis. The PCH was also stable, except in 2 of the cases with increasing W-angles. If we consider the W-angle and the PCH as parameters of the stability of bony deformation, we can conclude that the vertebral body remained remarkably stable in all except one of the patients with a presumably healthy bone structure, and consequently additional transpedicular spongioplasty did not provide any significant support. The isolated increase in the K-angle was associated with failure or migration of the implant. The only plausible explanation for an increasing K-angle without an associated increase in the W-angle is collapse of the disc space. Lindsey and Dick (1991) observed the same phenomena and suggested that an additional posterolateral fusion could prevent this recurrence of kyphosis. In our series, posterior fusion was performed in most of the cases but it failed to prevent an increase in the K-angles. This is in accordance with the findings reported by a long-term follow-up study of long Harrington rods and a short fusion technique (Akbarnia et al. 1994). The fate of a disc after a burst fracture is not known. Different patterns of healing or degeneration may be crucial for the success of posterior stabilization techniques. In case of a rapid disc collapse, a short-segment posterior instrumentation may be disproportionately loaded and therefore fail.

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## References

Aebi M. Die operative Behandlung von Wirbelsaülenverletzungen. Fortschr Med 1987; 28: 817–31.

Akbarnia B A, Crandall D G, Burkus K, Matthews T. Use of long rods and a short arthrodesis for burst fractures of the thoracolumbar spine. J Bone Joint Surg (Am) 1994; 76: 1629–35.

An H S, Vaccaro A, Cotler J M, Lin S. Low lumbar burst fractures. Comparison among body cast, Harrington rod, Luque rod, and Steffee plate. Spine 1991; 16: 440–4.

Bednar D A. Experience with the "fixateur interne": initial clinical results. J Spin Disor 1992; 5: 93–6.

Benson D R, Burkus J K, Montesano P X, Sutherland T B, McLain R F. Unstable thoracolumbar and lumbar burst fractures treated with the AO fixateur interne. J Spin Disor 1992; 5: 335–43.

Broom M J, Jacobs R R. Current status of internal fixation of thoracolumbar fractures. J Orth Trauma 1989; 2: 148–55.

Daniaux H. Transpedikuläre Reposition und Spongiosaplastik bei Wirbelkörperbrüchen der unteren Brust- und Lendenwirbelsaüle. Unfallchirurgie 1986; 89: 197–213.

Denis F, Ruiz H, Searls K. Comparison between square-ended distraction rods and standard round-ended distraction rods in the treatment of thoracolumbar spinal injuries. Clin Orth 1984; 189: 162–7.

Dick W. The fixateur interne as a versatile implant for spine surgery. Spine 1987; 12: 882–900.

Ebelke D K, Asher M A, Neff J R, Kraker D P. Survivorship analysis of VSP spine instrumentation in the treatment of thoracolumbar and lumbar burst fractures. Spine 1991; 16: 428–32.

Esses S I. The AO spinal internal fixator. Spine 1989; 14: 373–8.

Lin M R, Panjabi M M, Oxland T R. Functional radiographs of acute thoracolumbar burst fractures. Spine 1993; 18: 2431–7.

Lindsey R W, Dick W. The fixateur interne in the reduction and stabilization of thoracolumbar spine fractures in patients with neurologic deficit. Spine 1991; 16: 140–5.

Louis R. Les theories de l'instabilité. Rev Chir Orthop 1977; 63: 423–5.

Matsuzaki H, Tokuhashi Y, Matsumoto F, Hoshino M, Kiuchi T, Toriyama S. Problems and solutions of pedicle screw plate fixation of lumbar spine. Spine 1990; 15: 1159–65.

McAfee P C, Weiland D J, Carlow J J. Survivorship analysis of pedicle spinal instrumentation. Spine 1991; 16: 422–7.

McCormack T, Karaikovic E, Gaines R W. The load-sharing classification of spine fractures. Spine 1994; 19:1741–4.

McLain R F, Sparling E, Benson D R. Early failure of short-segment pedicle instrumentation for thoracolumbar fractures. J Bone Joint Surg (Am) 1993; 75 (2): 162–7.

Sasso R C, Cotler H B. Posterior instrumentation and fusion for unstable fractures and fracture-dislocations of the thoracic and lumbar spine. Spine 1993; 18: 45–60.

West J L, Ogilvie J W, Bradford D S. Complications of the variable screw plate pedicle screw fixation. Spine 1991; 16: 576–9.