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ORIGINAL STUDY

Short segment pedicle screw fixation for unstable T11-L2 fractures : with or without fusion ? A three-year follow-up study

Jin-Ho HWANG, Hitesh N. MODI, Jae-Hyuk YANG, Seong-Jun KIM, Suk-Ha LEE

From the Division of Spine Surgery, Department of Orthopedics, Konkuk University Hospital, Seoul, South Korea

In unstable thoracolumbar fractures T11-L2, exaggerated kyphosis at the end of treatment may predispose to late back pain and poor functional outcome. Short-segment (SS) (3 vertebrae) pedicle instrumentation has become a popular method of treatment. However the question to add a fusion or not is still under debate. The authors retrospectively evaluated the radiological and functional results in 74 patients who had undergone an SS pedicle screw fixation. They were divided into two groups : group 1 (39 patients) was the non-fusion group ; group 2 (35 patients) was the fusion group. In the non-fusion group the mean preoperative, immediate postoperative and final kyphosis angles at the fracture site were respectively 20.8° ± 6.4, 8.2° ± 4.8, and 15.2° ± 6.0. In the fusion group the corresponding angles were 26.6° ± 4.1, 7.9° ± 2.1, and 8.4° ± 2.4, which demonstrated a distinctly better final result ($p < 0.0001$). In the non-fusion group the preoperative, immediate postoperative and final follow-up visual analog scores (VAS) for back pain were respectively 7.3 ± 0.8, 3.9 ± 0.8, and 3.4 ± 0.9. In the fusion group the corresponding scores were 7.5 ± 1.0, 3.9 ± 1.1, and 1.6 ± 0.7 ; the final result pleaded again in favour of fusion ($p < 0.0001$). Moreover, there were significantly more implant-related complications (screw loosening and breakage) in the non-fusion group ($p < 0.0001$). The authors conclude that fusion is advisable to obtain a better final outcome with respect to kyphosis and pain, and to avoid implant-related complications. However, at least one other study has led to the opposite conclusion : the issue remains controversial.

Keywords : unstable thoracolumbar fracture ; T11-L2 ; short-segment fusion ; pedicle screw ; fusion versus non-fusion ; kyphosis ; back pain.

INTRODUCTION

Thoracolumbar junction (T11-L2) burst fractures involve thoracic as well as lumbar vertebrae. Anatomically, however, the thoracic spine differs from the thoracolumbar junction, which again differs from the mid and lower lumbar spine. Over the course of healing, deformity will progress to some extent under physiologic loading. An exaggerated kyphosis at the end of treatment may predispose to late back pain and a poor functional outcome (*7*). Pedicle screw devices allow immediate stable fixation, as the screws traverse all the three columns.

■ Jin-Ho Hwang, MD, Orthopaedic Fellow.
■ Hitesh N. Modi, MS, Research Fellow.
■ Jae-Hyuk Yang, MD, Orthopaedic Fellow.
■ Seong-Jun Kim, MD, Orthopaedic Resident.
■ Suk-Ha Lee, MD, PhD, Professor of Orthopaedic Surgery.
Division of Spine Surgery, Department of Orthopaedics, Konkuk University Hospital, Seoul, South Korea.
Correspondence : Suk-Ha Lee, Division of Spine Surgery, Department of Orthopaedics, Konkuk University Hospital, Seoul, South Korea. E-mail : osshlee@gmail.com

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Short-segment (SS) pedicle instrumentation has become a popular method since Dick *et al* (*5*) introduced the ''fixateur interne'' device. But the question "to fuse or not to fuse" in posterior short segment instrumentation for unstable thoracolumbar burst fractures is still under debate. Advocates of both techniques base their preference on variables such as maintenance of correction, pain, complications, operative time, blood loss etc...

Lindsey and Dick (*12*) reviewed the clinical results of 80 patients after thoracolumbar spinal fractures treated with a "fixateur interne". A fusion was added in only 30% of the cases, but no formal comparison was made between the non-fusion and the fusion group. Somehow, they felt that fusion was to be recommended. Wang *et al* (*22*) conducted a prospective randomized study in 58 patients with thoracolumbar and lumbar burst fractures, treated with short segment fixation. The radiographic parameters were significantly better in the non-fusion group ; there was no difference as to pain complaints. Their other arguments in favour of non-fusion were : elimination of donor site complications, preservation of more motion segments, and reduction of blood loss and operative time.

METHODS

The authors retrospectively evaluated the radiological and functional outcome in 74 patients whit unstable thoracolumbar spine fractures (T11-L2), operated in a single center, by two spine surgeons with similar experience (SHL, HJH). The first surgeon preferred SS pedicle screw fixation without fusion while the second one added a fusion. The non-fusion group (group 1) included 39 patients (28 males and 11 females), the fusion group (group 2) 35 patients (20 males and 15 females). There was no difference between both groups regarding the male/female ratio ($p = 0.187$, chi-square test). The average ages were 45.8 ± 16.5 and 40.5 ± 12.7 years in group 1 and 2, respectively ($p = 0.223$). All patients had unstable thoracolumbar fractures from T11 to L2 included. Involvement of T11, T12, L1 and L2 was noted, respectively in 5, 8, 20 and 6 patients in the non-fusion group and 7, 13, 11 and 4 in the fusion group : no significant difference ($p = 0.227$, chi-square test). In the non-fusion group 16 fractures were due to a motor vehicle accident (MVA) and 23 to a fall from a height (FFH) ; in the fusion group these numbers were 19 and 16 ($p = 0.254$).

The inclusion criteria were : 1. preoperative kyphosis $\geq 20°$ or anterior vertebral height loss $\geq 50\%$; 2. two or more than two columns involvement ; 3. no or partial neurological deficit ; 4. single level vertebral involvement. Patients with involvement of more than one vertebra or with complete neurological deficit were excluded.

Clinical examination, plain radiographs and CT-scan were routine. McAfee's (*14*) system was used to classify the fractures : all fractures were unstable burst fractures. The Frankel classification of neurological deficits was used, initially and at follow-up. A Frankel grade D and E was noted, respectively in 3 and 36 patients in the non-fusion group, and in 1 and 34 patients in the fusion group ; the post-operative and final scores were compared with the preoperative scores.

Surgical technique

The patients were positioned prone, in hyperextension, with the abdomen hanging free, thus preventing excessive intra-operative bleeding and achieving a significant initial reduction of the spinal fracture. All patients underwent a single-stage posterior short segment instrumentation (SS = one level above and one level below the fractured vertebra). The pedicle screws were inserted under C-arm guidance, one level above and one level below. Rods were then fixed to the four screws, following which the fracture was reduced. Cross fixation was not used. None of the patients underwent discectomy and/or laminectomy or another decompressive procedure. Posterior fusion was added in the fusion group (group 2), with cancellous bone grafts harvested from the posterior iliac crest.

All patients wore a custom-molded thoracolumbosacral brace for three months. They were followed clinically and roentgenographically. Kyphosis or lordosis were measured from the superior end-plate of the intact vertebra cephalad, to the inferior end-plate of the vertebra caudad to the fracture. A visual analog score (VAS) was used to evaluate pain before surgery, immediately after surgery, and at final follow-up.

RESULTS

The average follow-up period was 35.7 ± 4.6 months (range : 29-45) in the non-fusion group (group 1) and 38.8 ± 8.0 months (range : 29-52) in the fusion group (group 2) : the difference was not statistically significant ($p = 0.187$, Kruskal-Wallis test) (table I). Also the injury-to-surgery time

Table I. — Demographics, average preoperative, immediate postoperative and final kyphosis angles and pain score, mean operation time, estimated blood loss (EBL) and hospital stay

	Group 1 Non-fusion	Group 2 Fusion	p value
Number (male/female)	39 (28/11)	35 (20/15)	0.187
Average age ± SD	45.8 ± 16.5	40.5 ± 12.7	0.223
Average follow-up (months) ± SD	35.7 ± 4.6	38.8 ± 8.0	0.187
Injury-surgery interval (days) ± SD	4.8 ± 4.1	4.2 ± 3.0	0.965
Canal compromise % ± SD	39.2% ± 19.3	47.0% ± 13.5	0.052
Injury (vehicle/fall from height)	39 (16/23)	35 (19/16)	0.254
Preoperative kyphosis ± SD	20.8° ± 6.4	26.6° ± 4.1	< 0.0001*
Immediate postop. kyphosis ± SD	8.2° ± 4.8	7.9° ± 2.1	< 0.0001*
Final kyphosis ± SD	15.2° ± 6.0	8.4° ± 2.4	< 0.0001*
Preoperative VAS pain ± SD	7.3 ± 0.8	7.5 ± 1.0	0.277
Immediate postop.VAS pain ± SD	3.9 ± 0.8	3.9 ± 1.1	0.957
Final VAS pain ± SD	3.4 ± 0.9	1.6 ± 0.7	< 0.0001*
Operative time (min) ± SD	117 ± 33	152 ± 28	< 0.0001*
Estimated blood loss (ml) ± SD	315 ± 57	455 ± 78	< 0.0001*
Hospital stay (days) ± SD	11.6 ± 3.8	12.1 ± 4.1	0.524

* Indicates significant difference between non-fusion and fusion group.

interval (ISI) was similar in both groups ($p = 0.965$, Kruskal-Wallis test). The average percentage of canal compromise was 39.2% ± 19.3 in the non-fusion group, and 47.0% ± 13.5 in the fusion group ($p = 0.052$, Kruskal-Wallis test). The mechanism of injury (motor vehicle accident or fall from a height) was comparable in both groups ($p = 0.254$). Table I further shows the average thoracolumbar kyphosis angle and pain scores before and immediately after surgery and at final follow-up : in the non-fusion group (group 1) they were respectively 20.8° ± 6.4, 8.2° ± 4.8, and 15.2° ± 6.0. These results demonstrated that an important initial correction was only partially maintained : it decreased from 12.6° to 5.6°, which means a loss of 7° or 55% ($p < 0.0001$) (fig 1). In the fusion group (group 2) the corresponding kyphosis values were respectively 26.6° ± 4.1, 7.9° ± 2.1, and 8.4° ± 2.4, which suggested that a significant correction was maintained at final follow-up ($p = 0.887$) (fig 2). In other words, the correction decreased from 18.7° to 18.2°, which means a loss of only 0.5° or 3%. In the non-fusion group the preoperative, immediate postoperative and final follow-up visual analogue scores (VAS) for back pain were 7.3 ± 0.8, 3.9 ± 0.8, and 3.4 ± 0.9. In group 2, the fusion group, the corresponding values were 7.5 ± 1.0, 3.9 ± 1.1, and 1.6 ± 0.7. In other words, after an important initial improvement in the non-fusion group there was only little further improvement at final follow-up. In the fusion group the initial improvement was comparable with the non-fusion group ($p = 0.957$), but improvement continued up to the final follow-up, so that the difference between groups became very significant ($p < 0.0001$). The mean operative time was 117 ± 33 minutes in the non-fusion group, and 152 ± 28 minutes in the fusion group ($p < 0.0001$). The mean estimated blood loss (EBL) during the operation was 315 ± 57 ml in the non-fusion group, and 455 ± 78 ml in the fusion-group ($p < 0.0001$). There was no significant difference in the hospital stay ($p = 0.524$) between both groups (11.6 ± 3.8 days in the non-fusion and 12.1 ± 4.1 days in the fusion group). As to neurological improvement, all patients in both groups reached Frankel grade E at final follow-up.

Complications : there were 11 (11/39 = 28.2%) patients with implant-related problems in the non-fusion group versus 2 (2/35 = 5.7%) in the fusion group : the difference is significant ($p = 0.011$, chi-square test). Screw loosening was noted in 7 patients in the non-fusion group versus one in the fusion group ; screw breakage occurred in

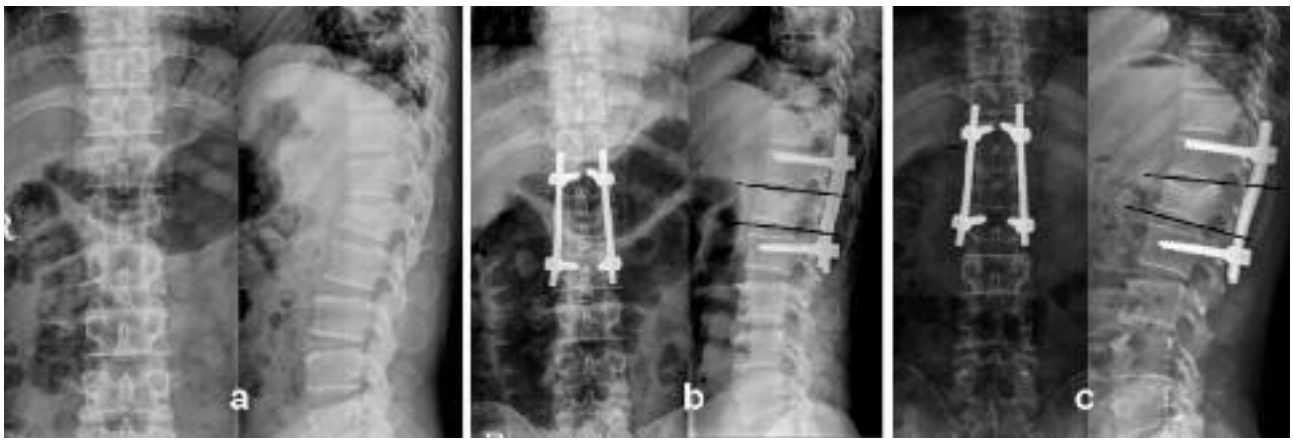

Fig 1. — Preoperative, immediate postoperative, and final follow-up AP and lateral radiograms of L1 fracture treated with short segment pedicle screw fixation *without* fusion (group 1). Although good correction was achieved immediately after the operation, it was not maintained at final follow-up (37 months).

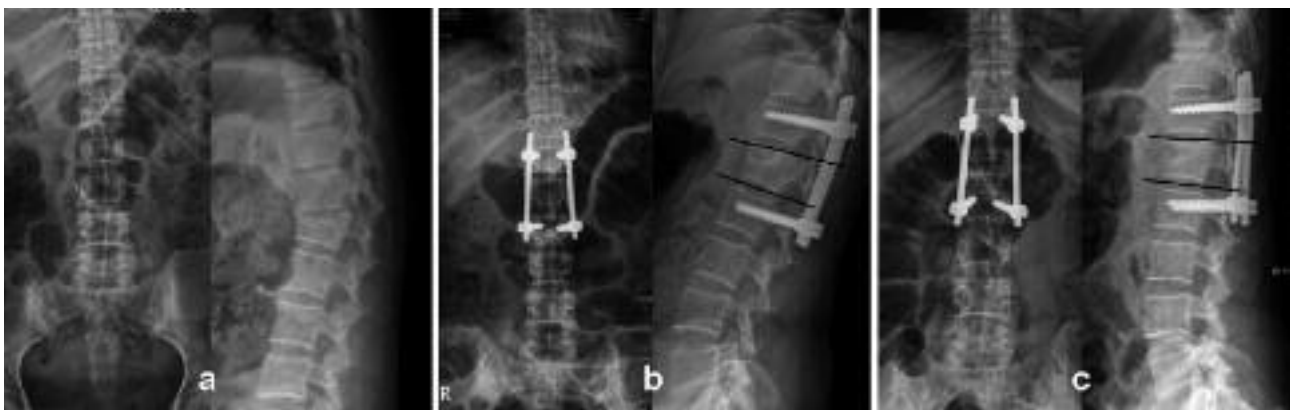

Fig 2. — Preoperative, immediate postoperative and final follow-up AP and lateral radiograms of L1 fracture treated with short segment pedicle screw fixation *with* fusion (group 2). Good correction was achieved immediately after the operation and was maintained at final follow-up (42 months).

4 patients in the non-fusion group versus one in the fusion group. All these problems probably increased back pain in the affected patients. Screw breakage necessitated a revision operation ; screw loosening was left untouched, because the patients denied further surgery.

DISCUSSION

The thoracolumbar junction is the most common level of spinal injury. Injury to both the anterior and middle columns results in a burst fracture with retropulsion of bone into the spinal canal. The surgical approach to burst fractures with significant canal compromise has always been controversial (*21*). Stability of the anterior column plays a pivotal role in the success or failure of the procedure. Transpedicular screw fixation offers superior three-column control and obviates the need for intracanal placement of hardware (*24*). Short-segment posterior fixation (SSPF) is the most common and simple treatment, offering the advantage of incorporating fewer motion segments in the fusion (*1,10,17*).

With or without fusion ?

Only a few authors have concentrated on the success or failure of short segment posterior fixation, completed with fusion (*13*) or not (*18*). Even rarer are those who compared non-fusion and fusion in a prospective randomized study : as stated above, Wang *et al* (*22*) found that the radiographic parameters were significantly better in the non-fusion group, while the low back pain outcome was practically similar in both groups. In sharp contrast with these statements were the results of the current study, where the fusion group did better as to kyphosis and back pain.

Loss of correction and subsequent pain

In the non-fusion group, the loss of correction may be mainly attributed to collapse of the injured disc, according to Sanderson *et al* (*18*), who treated 28 thoracolumbar burst fractures with short-segment fixation without fusion. They reported that the segmental motion did not reach the criteria of instability (more than 10° of angular change of one motion segment in the dynamic flexion-extension lateral views) (*24*). Mumford *et al* (*16*) preferred a non-operative management and noted that the body collapse progressed significantlyby +/- 8%. They also found that the residual deformity did not correlate with the pain complaints at follow-up. This was not confirmed by the current study, where the pain complaints at final follow-up were significantly more important in the non-fusion group with its progressing kyphosis, although the pain score was similar immediately after surgery in the non-fusion and in the fusion group. McLain *et al* (*15*) also noted that patients who had progressive kyphosis of more than 10° had substantially more pain than those who had little or no progression.

Short segment or long segment instrumentation ?

Tezeren and Kuru (*20*) reported that in a posterior-only approach for thoracolumbar burst fractures, radiographic parameters were better after long-segment instrumentation, while the clinical outcome was the same. On the other hand, short segment fusion offers the advantage of incorporating fewer motion segments in the fusion (*1,10,17*).

Prevention of implant failure

Implant failure is one of the criteria determining the success of the treatment. The current study clearly shows that in the non-fusion group 28.2% of the patients had implant-related complications versus only 5.2% in the fusion group ($p = 0.011$), which correlated with more severe back pain in the non-fusion group. A review of the literature shows that short segment (SS) posterior fixation without fusion led to a 9-54% incidence of implant failure and re-kyphosis in the long-term follow-up, while 50% of the patients with implant failure had moderate to severe pain (*2,4,10,19*). McLain *et al* (*15*) also reported that the high rate of hardware failure associated with a short segment (SS) fixation without fusion suggests that posterior screw fixation alone is not effective. In order to avoid hardware failure, several techniques have been developed to augment the anterior column in burst fractures : transpedicular bone grafting (*2,4*), placement of body augmenter (*11*), polymethylmethacrylate (PMMA) injection (*3*), anterior instrumentation and strut grafting (*9*). However, their effect should be studied separately in non-fusion and fusion groups.

CONCLUSION

The authors conclude that, although short-segment pedicle screw fixation without fusion yields satisfactory results in unstable thoracolumbar fractures T11-L2, fusion is advisable to maintain the postoperative kyphosis correction and to reduce the incidence of implant-related complications and back pain, despite diverging findings by Wang *et al* (*22*). The advantages of non-fusion are the elimination of donor site complications, the saving of motion segments, and the reduction of blood loss and operative time at initial treatment, which is crucial for polytraumatized or critical patients (*6,22*). But a little more operative time and blood loss, due to a fusion, would grant less low back pain and implant related complications. A weakness of this study is the fact that it was not a randomized study.

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