Treatment of unstable thoracolumbar junction fractures: short-segment pedicle fixation with inclusion of the fracture level versus long-segment instrumentation

Mauro Dobran, Davide Nasi, Denise Brunozi, Lucia di Somma, Maurizio Gladi, Maurizio Iacoangeli, Massimo Scerrati

Abstract

Background The surgical management of thoracolumbar burst fractures frequently involves posterior pedicle screw fixation. However, the application of short- or long-segment instrumentation is still controversial. The aim of this study was to compare the outcome of the short-segment fixation with inclusion of the fracture level (SSFIFL) versus the traditional long-segment fixation (LSF) for the treatment of unstable thoracolumbar junction fractures.

Methods From December 2009 to February 2014, 60 patients with unstable thoracolumbar junction fractures (T11-L2) were divided into two groups according to the number of instrumented levels. Group 1 included 30 patients treated by SSFIFL (six-screw construct including the fracture level). Group 2 included 30 patients treated by LSF (eight-screw construct excluding the fracture level). Local kyphosis angle (LKA), anterior body height (ABH), posterior body height (PBH), ABH/PBH ratio of fractured vertebra, and Asia Scale Impairment Scale were evaluated.

Results The two groups were similar in regard to age, sex, trauma etiology, fracture level, fracture type, neurologic status, pre-operative LKA, ABH, PBH, and ABH/PBH ratio and follow-up ($p > 0.05$). Reduction of post-traumatic kyphosis (assessed with LKA) and restoration of fracture-induced wedge shape of the vertebral body (assessed with ABH, PBH, and ABH/PBH ratio) at post-operative period were not significantly different between group 1 and group 2 ($p = 0.234$; $p = 0.754$). There was no significant difference between the two groups in term of correction loss at the last follow-up too (LKA was $15.97° ± 5.62°$ for SSFIFL and $17.76° ± 11.22°$ for LSF [$p = 0.427$]). Neurological outcome was similar in both groups.

Conclusions Inclusion of fracture level in a short-segment fixation for a thoracolumbar junction fractures results in a kyphosis correction and in a maintenance of the sagittal alignment similar to a long-segment instrumentation. Finally, this technique allowed us to save two or more segments of vertebral motion.

Keywords Thoracolumbar burst fractures · Pedicle screw · Long-segment fixation · Short-segment fixation · Inclusion of fracture level

Introduction

Most traumatic thoracolumbar fractures occur at the thoracolumbar junction (T11-L2) [5, 9]. Despite the high incidence of this pathology, currently there are no evidence-based guidelines for the right approach and instrumentation techniques [1, 2, 10]. Actually, several surgical techniques are available for the treatment of thoracolumbar fractures: posterior, anterior, open, minimally invasive, and combined posterior-anterior ones. Moreover, which levels should be instrumented to achieve a successful recovery is the important question in the decision-making process. At present, the application of short- or long-segment pedicle screws fixation is still under debate [8]. Traditional methods of stabilizing the injured spine included the instrumentation at least of two vertebrae above and two vertebrae below the fracture in order to provide good stabilization minimizing the risks of post-traumatic kyphosis and implant breakage [4]. However, this technique also results in a relevant reduction of the vertebral...
motion. More recently, short-segment instrumentation with pedicle screws and rods (inclusion of one level above and one level below the fractured vertebra) grants the reduction of surgical time and hospital costs and preserves segments of motion at the lumbar spine [4, 6, 8].

However, disadvantages of this method, such as inadequate long-term reduction, increases in kyphosis, and pain, have been reported [2–7]. To prevent failure, some authors advocate the insertion of screws at the fractured vertebra [4, 6].

In this retrospective study, we have tried to compare the traditional LSF (two levels above and two levels below excluding the fracture level) and the SSFIFL (one level above and one level below including the fracture level) analyzing the correction of deformity, maintenance of the correction, and prevention of fixation failure in thoracolumbar burst fractures.

Materials and methods

From December 2009 to February 2014, 60 patients with acute, traumatic fractures of the thoracolumbar junction (T11-L2) have been treated with posterior pedicle screw fixation and fusion in our department. The patients included in this retrospective study had: a single-level fracture between T11–L2, unstable acute fracture (surgical indications included more than 50% acute vertebral body height, local kyphosis of more than 15°, burst-type fracture with more than 25% retropulsion into the canal); <3 weeks from the time of injury and integrity of at least one pedicle in the fractured vertebra (for patients with fractured level screws).

Patients were evaluated according to their age, gender, trauma etiology, fracture level, fracture type according to the Magerl classification [7], neurologic status according to the American Spinal Injury Association (ASIA) grading system, and follow-up (Table 1).

The patients were divided into two groups according to the number of instrumented levels. Group 1 included 30 patients treated by short-segment fixation with inclusion of the fracture level (SSFIFL). The SSFIFL were performed using two screws one level above and below the fracture and at least one pedicle screw at the fracture level. Group 2 included 30 patients treated by long-segment fixation (LSF) with eight screws: two levels above and below the fracture.

All operations were performed by the senior author, using the same instrumentation system, with screws size chosen according to the vertebra size (6.5 × 45-mm screws and 5-mm rods most of the time). Reduction of the fracture and indirect decompression of the spinal cord were accomplished by means of the rod contouring and the compression-distraction forces applied before tightening the screws. Laminectomy was performed according to the presence of compression on neural tissue in pre-operative imaging.

Preoperative, post-operative, and most recent follow-up radiographs (minimum 18 months) and/or CTs of the patients have been evaluated. Different parameters were used to compare the two groups including:

- Local kyphosis angle (LKA): Cobb angle between the superior and the inferior end plates of the fractured vertebra; this parameter is used to assess the immediate post-operative reduction of local post-traumatic kyphosis and the maintenance of the correction at the follow-up. The difference between immediate post-operative and follow-up kyphotic angles was also registered.
- Anterior body height (ABH) of the fractured vertebra: the anterior body height of the injured vertebra was evaluated on lateral radiographs or CT sagittal sections and measured in millimeters.
- Posterior body height (PBH) of the fractured vertebra: the posterior body height of the injured vertebra was evaluated on lateral radiographs or CT sagittal sections and measured in millimeters.
- ABH/PBH ratio of the fractured vertebra: using the ratio of the heights of the anterior and posterior vertebral walls (on the lateral views of the injured vertebral body), the sagittal deformity of the fractured vertebra has been calculated.

Direct and/or indirect signs of implant failure (such as screw breakage, rod displacement/breakage, screw head dislodgement) were checked at follow-up imaging. Neurologic assessment was tested using the American Spinal Injury Association (ASIA) grading system. More evaluated parameters were operative time and surgical complications.

The SPSS (Statistical Package for the Social Sciences) 18.0 software package was used for the statistical analysis of the data. Chi-squared statistics were employed in the comparison of categorical measurements between groups, and independent t tests were employed for the comparison of numerical measurements between groups. The statistical significance level was taken as 0.05 in all tests.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Results

The two groups were similar with regard to age, sex, trauma etiology, fracture level, fracture type, neurologic status, and follow-up (p > 0.05). Patients’ demographics, trauma etiology, level and type of fractures, neurologic status and follow-up are
shown in Table 1. The mean age was 49.23 ± 19.27 for group 1 (SSFIFL) and 52.63 ± 19.43 for group 2 (LSF) respectively with no significant difference ($p = 0.548$). Between groups 1 and 2, there were no significant differences for fracture level and type ($p = 0.320; p = 0.691$). Pre-operative neurological status was similar between group 1 and 2 according to the ASIA impairment scale ($p = 0.172$). Also, the mean follow-ups were similar for both groups too (mean, 32.5 months for group 1 and mean 30.8 months for group 2, ($p = 0.579$). Pre-operative-ly, the groups did not differ for LKA, ABH, PBH, and ABH/ PBH ratio (Table 2).

**Local kyphosis angle (LKA)**

The average pre-operative LKA was 20.96° ± 4.74° in group 1 (SSFIFL), while in group 2 (LSF) was 22.59° ± 5.89 ($p = 0.234$). Post-operative correction was slightly better in group 1 than in group 2. In fact, the mean post-operative LKA was 14.2° ± 6.5° for group 1 (SSFIFL) and 17.13° ± 11.63° for group 2 (LSF), with an average correction of 6.73 and 5.46°, respectively. However, this difference was not statistically significant ($p = 0.243$). Moreover, there was no significant difference of correction loss between the two Groups at the last follow-up. In fact, the mean LKA at last follow-up was 15.97 ± 5.62° for group 1 of SSFIFL and 17.76 ± 11.22° for group 2 of (LSF). Correction loss in group 2 (0.63°) was slightly less than in group I (1.74°) without no statistical relevance ($p = 0.427$). These results are summarized in Table 2, while changes in LKA over the time are shown in Fig. 1. To conclude, the two groups were similar both in terms of post-operative sagittal alignment restoration and correction loss at last follow-up.

**ABH/PBH ratio of the fractured vertebra**

The average ABH/PBH ratio was 0.67 ± 0.15 preoperatively, 0.75 ± 0.23 postoperatively, and 0.71 ± 0.15 at last follow-up in group 1 (SSFIFL), while it was 0.61 ± 0.21 preoperatively,
0.77 ± 0.18 post-operatively, and 0.76 ± 0.29 at last follow-up in group 2 (LSF) (Table 2). The results show the absence of statistical significant differences between groups 1 and 2 in terms of restoration of fractured vertebral body shape ($p = 0.551$) and maintenance of the restoration over the time ($p = 0.831$). Changes of the ABH/PBH ratio, which reflect the fracture-induced wedge shape of the vertebral body, are presented in Table 2. Surgery resulted in an almost complete reconstruction of the original shape of the vertebral body in both groups. At the time of follow-up, we recorded only a slight, but insignificant reduction of the ABH/PBH ratio in group 1 rather than in group 2.

### Anterior body height (ABH) of the fractured vertebra

The anterior vertebral height was $16.62 \pm 4.32$ mm preoperatively, $19.02 \pm 4.44$ mm postoperatively, and $18.88 \pm 4.90$ mm at the follow-up in group 1 (SSFIFL) and it was $15.38 \pm 4.31$ mm preoperatively, $17.83 \pm 6.65$ mm postoperatively, and $17.11 \pm 5.22$ at

![Fig. 1](image-url)

The mean local kyphosis angle of group 1 SSFIFL (continuous line) and group 2 LSF (dotted line) pre-operatively, immediately after surgery, and at last follow-up. There were no significant differences between the preoperative, post-operative, and follow-up measurements of the local kyphosis angle in the two groups ($p = 0.234; p = 0.243; p = 0.427$).
were treated conservatively with complete resolution. Three wound infections in group 2. All these complications included one wound infection in group 1 and ing screw breakages or loosening in both groups.

Complications included one wound infection in group 1 and three wound infections in group 2. These results were not statistically significant for either of the groups (Table 2).

Posterior body height (PBH) of the fractured vertebra

The posterior vertebral height was 24.5 ± 5.05 mm preoperatively, 25.71 ± 3.96 mm postoperatively, and 25.65 ± 5.54 mm at the follow-up in group 1 (SSFIFL) and it was 24.94 ± 5.77 mm preoperatively, 25.59 ± 5.05 mm postoperatively, and 23.93 ± 4.96 at the follow-up in group 2 (LSF). These results were not statistically significant for either of the groups (Table 2).

Neurological outcome

In group 1 (SSFIFL), based on the ASIA scale, at admission 19 patients (63.33 %) had no neurological deficit (ASIA E); five patients (16.66 %) had ASIA D, three patients (10 %) had ASIA C, one patient (3.33 %) had ASIA B, and two patients (6.66 %) had complete injury (ASIA A).

Follow-up neurological status was assessed as following: ASIA E (23 patients: 76.66 %), ASIA D (three patients: 10 %), ASIA C (two patients: 6.66 %), ASIA B (one patient: 3.33 %) and ASIA A (one patient: 3.33 %). In conclusion, seven patients out of 11 (63.3 %) showed neurological improvement (Table 3).

In group 2 (LSF), at admission, 20 patients (66.66 %) had ASIA E; five patients ASIA D (16.66 %); one patient ASIA C (3.33 %); three patients ASIA B, and one patient (3.33 %) ASIA A. At follow-up in group 2, 23 patients (76.66 %) had no neurological deficit (ASIA E), three patients (10 %) ASIA D, three patients (10 %) ASIA C, one patient (3.33 %) ASIA B, and another patient (3.33 %) ASIA A. In this group, six patients out of ten (60 %) recovered at least one ASIA grade (Table 3). Statistical analysis showed no difference between the two groups (p > 0.05).

Others results

Mean operative time was significantly shorter in the group 1 of SSFIFL (148.5 ± 21.54 min) than in group 2 of LSF (172 ± 22.19 min; sp < 0.05). There were no implant failures, including screw breakages or loosening in both groups. Complications included one wound infection in group 1 and three wound infections in group 2. All these complications were treated conservatively with complete resolution.

Discussion

The best surgical management of thoracolumbar burst fractures is still a matter of discussion and currently there are no evidence-based treatment guidelines for the proper surgical approach and the instrumentation technique [1–5]. Posterior pedicle fixation is the most frequent surgical treatment for thoracolumbar fractures because it grants a rigid fixation with low morbidity [9]. Moreover, determining which levels should be instrumented to achieve a successful recovery is an important step in the decision-making process. Nowadays, the application of short- or long-segment pedicle screws is still controversial [2–10]. Traditional methods to stabilize the injured spine include two vertebrae above and two vertebrae below the injury to provide stabilization enough to enable early mobilization and to recover normal activities, without incurring the risks of posttraumatic kyphosis, implant breakage, and late neurologic deficit [4]. However, they also result in a motionless spine due to the fixing of five vertebral segments at least. More recently, short-segment fixation with insertion of pedicle screws one level below and one level above the fractured vertebra has gained increased popularity cause a theoretic reduction of surgical time and hospital costs along with saving more segments of motion [4, 6, 8]. Besides, disadvantages of this method such as inadequate long-term reduction and instrumentation failure with postoperative kyphosis have also been reported [7, 11]. To prevent these events, some authors advocate the positioning of peduncular screws at the fractured vertebrae to reinforce the construct [4, 6].

A recent meta-analysis of the literature, regarding the use of pedicle screw fixation for traumatic fractures of the thoracic and lumbar spine, included only five randomized and three quasi-randomized controlled trials (448 patients). Overall, in these trials, five different comparisons of methods of pedicle fixation were tested [2]. The critical analysis of the eight trials found not significant advantage of one method over another.

Among these eight trials, two trials compared short-segment instrumentation versus long-segment instrumentation [4, 11]. Tezeren et al. observed that final outcome regarding local kyphosis and anterior body compression is better in the long-segment instrumentation [11]. The other two trials compared posterior instrumentation with fracture-level screw incorporation versus posterior instrumentation alone. This comparison was assessed in 152 consecutive participants with fractures between T10 and L3 by Farrokhi et al. [3] and Guven et al. [4]. At final follow-up, the group with fracture-level screw incorporation showed statistically significantly better clinical outcomes in the correction of local kyphosis angle and in anterior body height compression compared with the “bridging group”.

Some other retrospective series recently compared short-segment stabilization with and without screws at the level of the fracture [6, 8]. All these studies found that better correction is achieved in short-segment applications combined with screws placed at the fractured level compared with short-segment fixations where no screws are used at all. Besides,
the screws at the fractured level reduce the correction loss in the long period compared with short fixation without fracture inclusion.

Other authors have suggested a combined short posterior transpedicular fixation and staged anterior corpectomy and reconstruction in an attempt to reunite the advantages of both the posterior approach (complete initial kyphosis correction, smaller blood loss in case of emergency decompression) and the anterior approach (reconstruction of the weight-bearing anterior column, complete anterior spinal canal decompression in case of neurological deficit) [9]. However, this technique required two operations, additional cost, and higher perioperative morbidity and pain. In the author’s opinion, this combined approach should be reserved in cases of severe destruction of anterior column. In fact, in this condition, the only posterior approach may be insufficient to resist a physiological axial load and an efficient reconstruction of the anterior load-bearing column was mandatory to prevent a secondary loss of correction and implant failure.

To the best of our knowledge, no previous studies have compared the outcomes of the traditional long-segment fixation (LSF) and short-segment fixation with inclusion of the fracture level (SSFIFL) in unstable thoracolumbar junction burst fractures (T11–L2).

The present retrospective study compares two patients’ groups: the former underwent a short-segment posterior fixation with inclusion of the fracture level (SSFIFL) and the latter a traditional long-segment fixation with two levels above and two levels below the fracture (LSF). The groups were similar with regard to age, sex, trauma etiology, fracture level, fracture type (according to the Magerl classification), neurologic status (according to the ASIA impairment scale), and follow-up. Homogeneity was observed also in terms of local kyphosis angle (LKA), anterior body height (ABH), posterior body height (PBH), and ABH/PBH ratio at preoperative evaluation. Reduction of post-traumatic kyphosis (assessed with LKA) and restoration of fracture-induced wedge shape of the vertebral body (ABH/PBH ratio, ABH and PBH) at immediate post-operative period were not significantly different between group 1 of SSFIFL and group 2 of LSF. There was also no significant difference between the two groups in terms of loss correction at the last follow-up.

The present study confirms that intraoperative fracture reduction and correction of sagittal deformity can be easily achieved via the placement of screws at the fracture level, according to the hypothesis of Guven et al. [4]. Moreover, the use of screws placed within the fractured vertebra can enhance the stability of construct and prevent loss correction over the time [6, 8]. In many studies, the correction of the kyphosis angle observed in the early postoperative period decreased in long-term controls [1]. In our experience, a short instrumentation with inclusion of fracture level ensures the same loss correction of long construct.

In this series, SSFIFL offers significant advantages such as incorporating fewer motion segments in the fusion, shorter operative time, and maintenance of the correct sagittal alignment. Moreover, the neurological outcome was similar in both group: seven patients out of 11 (63.3 %) improved in group 1 and six patients out of ten (60 %) improved in group 2 of at least one ASIA grade.

**Table 3** Neurological outcome of two groups

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Conclusions

Inclusion of fracture level in a short-segment fixation for a thoracolumbar junction fractures results in a kyphosis correction and in a maintenance of the sagittal alignment similar to a long-segment instrumentation. Also, neurological outcome was also similar for the two groups. Finally, this technique allowed to save two or more segments of vertebral motion.

Compliance with ethical standards

Funding  No funding was received for this research.

Conflict of interest None.

Ethical approval  All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent  Informed consent was obtained from all individual participants included in the study.

References

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