



Short-Segment Versus Long-Segment Stabilization in Thoracolumbar Burst Fracture: A Review of the Literature

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Abstract

Background: Thoracolumbar fractures are the most common traumatic fractures of the spinal column. They result from a compression load without the associated shear, rotational, or translational components. Although neurological compression and spine instability are the recognized indications for surgery, it is unclear which approach should be used to stabilize the spine. Short-segment (SS) stabilization involves the upper and lower levels of the fractured vertebra, while use of more extended instrumentations is defined as long-segment (LS) stabilization. The SS stabilization is the most common approach; nevertheless, its superiority to LS stabilization is not clear yet.

Objectives: The aim of the present study was to conduct a review of the literature to find evidence supporting SS or LS posterior stabilization.

Methods: A review of the English literature was conducted to select prospective, randomized studies, comparing the effectiveness of stabilization with short and long pedicle screws for thoracolumbar burst fractures in adults.

Results: Three studies were selected, including a total of 89 patients. Overall, 40 patients were treated with SS stabilization and 49 with LS stabilization. No significant difference was found between the groups in terms of preoperative and postoperative parameters, as the level of correction was quite similar. However, the measured parameters were significantly different in the follow-up, indicating a major loss of correction in the SS stabilization group.

Conclusions: Based on small-scale studies, a major loss of correction is associated with posterior SS stabilization. However, larger studies are needed to confirm this finding and to verify differences in the clinical outcomes.

Keywords: Short Instrumentation, Long Instrumentation, Stabilization, Burst Fracture, Adjacent Segment Disease

1. Background

Thoracolumbar fractures are the most common traumatic fractures of the spinal column. A burst fracture results from a compression load, without the associated shear, rotational, or translational components (1, 2). These fractures are majorly attributed to transition from the rigid thoracic segment augmented with ribs and sternum to the more mobile lumbar segment (1, 2). They frequently result from high-energy injuries following motor vehicle accidents or falls.

Due to the high-energy impact, thoracolumbar fractures are often associated with neurological symptoms. Also, since the spinal cord ends at L1-L2 level, the symptoms can differ (1, 2). In the presence of neurological compression or instability, surgery is the main treatment option, despite lack of consensus in the literature regarding the superiority of anterior or posterior approaches (3). In the

absence of neurological symptoms or mechanical instability, selection of treatment is even more controversial with respect to the patient's pain, function, and potential to return to work (3).

In posterior techniques, we can distinguish between short-segment (SS) internal fixation, where pedicle screws are inserted from the superior and inferior vertebrae to the fractured vertebra, and long-segment (LS) internal fixation, where 2 or more levels above and below the fractured vertebra are instrumented. Currently, SS internal fixation is the most common technique with open or minimally invasive access for patients with or without neurological symptoms and fusion (4, 5); nevertheless, no reliable evidence is available in the literature regarding its advantages to LS fixation.

2. Objectives

The aim of this study was to review the literature on SS and LS stabilization in order to verify the quality of selected articles and report possible conclusions.

3. Methods

3.1. Evidence Acquisition

The search was conducted in February 2014 in major medical search engines, including PubMed (www.pubmed.com), Cochrane Central Register of Controlled Trials, EMBASE (<http://www.elsevier.com/online-tools/embase>), WHO, and International clinical trials registry platform (<http://www.who.int/ictpr/en/>), using the following keywords: “short versus long instrumentation”, “short versus long posterior stabilization”, “thoracolumbar fracture”, and “surgery”.

Prospective randomized studies, comparing the effectiveness of SS and LS stabilization for thoracolumbar burst fractures in adults, were included in this review; on the other hand, cadaver models and biomechanical papers were excluded. No restrictions for language or date of publication were considered. The full-text of relevant articles and references was then thoroughly reviewed by 2 independent investigators (CZ and CW) to choose papers for analysis in the review. The initial literature search yielded 53 citations, only 9 of which were considered relevant after reading the abstracts; also, three articles were found relevant after a thorough examination of papers and their references. Finally, studies by Tezeren and Kuru (6), Lee et al. (7), and Sapkas et al. (8) were included in the present review.

Assessment of methodological quality

The study by Tezeren and Kuru (6) is the first to compare LS and SS posterior stabilization for thoracolumbar burst fractures from T12 to L2 level. This prospective study included 18 patients, randomized into 2 groups. The inclusion criteria were as follows: 1) the sagittal index exceeding 15° or loss of anterior body height exceeding 50%; and 2) absence of neurological symptoms. However, the exclusion criteria were not reported, and the surgical team was not described. Two instrumentation systems were used in this study, including an AO internal fixator (Synthes Corp., Bochum, Germany) for SS stabilizations and Isola device (Acromed, Cleveland, OH) for LS stabilizations (introducing a hypothetic confounding factor). In the materials and methods section, the preoperative, postoperative and follow-up analyses of local kyphotic angle were performed, based on the Cobb angle; nevertheless, no results were successively reported.

The study by Lee et al. (7) included 36 patients, who were randomized into 3 groups (15 patients in group I, 11 patients in group II, and 10 patients in group III). Patients from groups I and II were treated via SS internal fixation and allowed to bear weight after 10 - 14 days and 3 days, respectively. Patients from group III were treated by LS internal fixation and allowed to bear weight after the third postoperative day, similar to group II. Only groups II and III were included in our review to exclude bed rest as a confounding factor.

In the mentioned study, the inclusion and exclusion criteria were not clearly established. Although the title focused on thoracolumbar fractures, L3-4 levels were also included. They reported an average surgery duration of 90 minutes, without distinguishing any differences in surgery duration between the groups or reporting any specific blood loss. The mean follow-up period was 13.7 months (range, 3 - 27 months), and the quality of information reduced due to the loss of correction for short-term follow-up patients.

The most recent paper by Sapkas et al. (8) had several gaps in its methodology. The authors stated that the study was part of a larger prospective, randomized research. In fact, they reviewed data from another project, without specifying if the study was planned before enrolling the first patient. They also did not report if randomization was conducted with respect to instrumentation length. The indications for SS and LS stabilizations were not mentioned either, which is an important confounding factor for the statistical power of the results and conclusions. It should be noted that the exclusion criteria were pathological fractures and multilevel injuries, while a long instrumentation construct was applied in 2 patients to stabilize both thoracic T12 and lumbar L3 fractures.

4. Results

The total number of patients, who underwent SS and LS instrumentations, was 40 and 49, respectively. The majority of patients were 30 - 40 years old, and the number of male patients was higher than females (61 out of 89 patients). Lee et al. (7) and Tezeren and Kuru (6) considered normal neurological function as an inclusion criterion, unlike Sapkas et al. (8) (Table 1). Based on the findings reported by Sapkas et al. (8) and Tezeren and Kuru (6), the operation time of SS instrumentation was shorter than that of LS instrumentation, and the level of blood loss was lower in this group; in these studies, the differences were significant (Table 2).

Tezeren and Kuru (6) used a clinical parameter, known as the low-back outcome score (LBOS) by Greenough and Fraser (9), besides radiologic parameters, anterior body

Table 1. The Clinical Aspects of the Included Studies

Paper	Type	Total PZ	M/F ratio	Age	Fracture Level	Fracture Classification	Neurological Status
Sapkas et al. (2010)	Prospective randomized	50	32/18	32 (13 - 55)	T11-L2	A3.3 on AO classification	Variable
Lee et al. (2009)	Prospective randomized	21	14/7	43.7 (21 - 83)	T12-L4 (T8)	Not reported	Intact
Tezeren et al. (2005)	Prospective randomized	18	15/3	33.4 (17 - 56)	T12-L2	Type B on Denis classification	Intact

Table 2. The Characteristics, Operation Time, and Blood Loss in Different Groups from Different Studies

Paper	SS-PZ	F	FU	PZ Length	F	FU	PB	WB	SS-OT	LS-OT	SS-BL	LS-BL
Sapkas et al. (2010)	20 (12M + 8F)	Yes	34 m (25 - 70)	30 (20M + 10F)	Yes	36 m (24 - 72)	3 m		170 min (140 - 220)	220 min (190 - 300)	1050 mL (350 - 1800)	1200 mL (550 - 2100)
Lee et al. (2009)	11	No	13.7 m (3 - 27)	10	No	13.7 m (3 - 27)	3 m	3 - 4 d	Not reported	Not reported	Not reported	Not reported
Tezeren et al. (2005)	9	Yes	29 m (23 - 38)	9	Yes	29 m (24 - 40)	3 m	Not reported	152 min (120 - 200)	188 min (150 - 240)	411 mL (250 - 600)	550 mL (300 - 800)

Abbreviations: BL, blood loss; d, days; F, fusion; F, female; FU, follow-up; LS, long-segment instrumentation; M, male; m, months; OT, operation time; PB, postoperative bracing time; SS, short-segment instrumentation; WB, weight bearing.

height compression (measurement of the anterior body height of the injured and uninjured adjacent vertebrae above and below) as proposed by Mumford et al. (10), and sagittal index described by Farcy et al. (11). The local kyphotic angles mentioned in the materials and methods section were not reported in the results section. The radiographic parameters are presented in Table 3. As evidenced by LBOS, there was no significant difference between the SS and LS groups in terms of the clinical symptoms in the follow-up.

On the other hand, Lee et al. (7) used the Denis work status assessment scale and Denis pain score, along with radiographic parameters, Cobb angle (angle between the superior endplate of the upper vertebra and inferior endplate of the lower uninjured vertebra), and percentage of anterior height loss (anterior body height compression by Tezeren and Kuru) (6). Preoperative, postoperative, and follow-up assessments were performed on these parameters; the radiographic parameters are presented in Table 3.

As previously noted, there was no significant difference in preoperative and postoperative radiographic parameters, confirming the similarity of corrections. Nevertheless, a significant difference was found in the parameters at the follow-up. The mean wedge angle loss was 5.91 and 2.87 in the SS and LS groups, respectively, showing a major loss of correction associated with SS instrumentation. Considering the clinical parameters, Lee et al. (7) indicated better responses in the follow-up for the LS group versus the SS group, based on the Dennis pain scores, while insignificant differences were reported on the Denis work status assessment scale.

Sapkas et al. (8) evaluated 4 parameters to compare the effectiveness of 2 techniques in their study. These pa-

rameters included LBOS (9), segmental kyphosis (angle between the inferior endplate of the superior adjacent vertebra and the superior endplate of the inferior adjacent vertebra), back index, and overall disc height (average of anterior and posterior disc height). The parameters were evaluated preoperatively and postoperatively, and follow-up analyses were incorporated. The radiographic parameters are presented in Table 3.

No significant difference was found between the groups in the preoperative and postoperative parameters, and corrections were quite similar. However, the measured parameters were significantly different in the follow-up, showing a major loss of correction in the SS group. As reported by Tezeren and Kuru (6), no significant differences were observed in terms of pain between the groups in the follow-up. Although there was no significant difference between the groups in the pre- and postoperative measurements, a significant difference was reported in the follow-up, confirming a major loss of correction in the SS group.

5. Discussion

Thoracolumbar spine fractures are the most common traumatic spine fractures. They represent more than half of all vertebral traumatic fractures and are mainly caused by high-energy impact, such as traffic accidents or falls (12). The high incidence of these fractures is probably due to movement from the very rigid thoracic segment augmented by the ribs and sternum to the mobile lumbar spine (13).

When neurological symptoms are absent and the fracture is considered stable, conservative treatment is advocated, as it is as effective as surgical treatment for pain

Table 3. The Preoperative, Postoperative, and Follow-Up Assessments of Parameters in Different Groups

	Pre-ABC		Post-ABC		Fu-ABC		Pre-CA		Post-CA		Fu-CA		Pre-SI		Post-SI		Fu-SI	
	SS	SL	SS	SS	SL	SS	SS	SL	SS	SS	SL	SS	SL	SS	SL	SL	SS	SL
Tezeren et al. (2009)	41 ± 14%	40 ± 11%	5 ± 1%	4 ± 1%	15 ± 1%	8 ± 1%			Not reported				19 ± 1°	20 ± 2°	4 ± 1°	3 ± 1°	10 ± 1°	6 ± 1°
Lee et al. (2009)	38.5% (10-60)	38.7% (31-45)	14.3% (4-30)	13.7% (4-29)	30.4% (20-45)	19.9% (8-30)	21.2° (6-29)	15.7° (6-29)	18.8° (2-31)	7.8° (0-18)	18° (5-28)	10.1 (4-19)						
	Pre-BI		Post-BI		Fu-BI		Pre-CA		Post-CA		Fu-CA		Pre-SK		Post-SK		Fu-SK	
	SS	SL	SS	SS	SL	SS	SS	SL	SS	SS	SL	SS	SL	SS	SL	SL	SS	SL
Sapkas et al. (2010)	0.60 (0.38-0.70)	0.60 (0.40-0.82)	0.92 (0.60-1.00)	0.94 (0.65-1.00)	0.90 (0.55-1.00)	0.92 (0.70-1.00)	17° (8-29)	17.5° (9-30)	5° (0-9)	3° (0-8)	8.5° (1-22)	6° (0-10)	4 (1-13)	9.5 (-3-21)	-9 (-20-+5)	-9 (-18-+2)	4.5 (-3.5-24)	40 (-10-190)

Abbreviations: Fu-ABC, follow-up anterior body compression; Fu-BI, follow-up Beck index; Fu-CA, follow-up Cobb angle; Fu-SK, follow-up segmental kyphosis; Fu-SI, follow-up sagittal index; Post-ABC, postoperative anterior body compression; Post-BI, postoperative Beck index; Post-CA, postoperative Cobb angle; Post-SI, postoperative sagittal index; Post-SK, postoperative segmental kyphosis; Pre-ABC, preoperative anterior body compression; Pre-BI, preoperative Beck index; Pre-CA, preoperative Cobb angle; Pre-SI, preoperative sagittal index; Pre-SK, preoperative segmental kyphosis.

control, functional improvement, and return to work; nevertheless, surgery may be beneficial for polytraumatized patients (3, 14). When neurologic compression is present or the fracture is considered unstable, surgery is the first treatment option (5, 15). Surgeries with anterior or posterior access (or both), fusion or non-fusion surgeries, and open or minimally invasive operations are only some of the possible surgical options presented in the literature.

Posterior stabilization is considered the gold standard for nonneurological patients with unstable fractures; it is also valid in patients who require minimal decompression (16-21). This surgery with a minimally invasive approach is suggested for patients with several stable fractures, who have a history of conservative treatment and aim to return to work and perform different activities as soon as possible (16-21).

The present review aimed to determine if SS and LS instrumentations are associated with different outcomes. Considering the mentioned conflicting data, it should be sufficient to draw conclusions about particular aspects, such as operation time, blood loss, and loss of correction associated with SS and LS instrumentations. Overall, the main recognized objectives in the treatment of burst fractures are prevention of kyphotic deformity, pain relief, return to work, and prevention of adjacent segment disease (ASD).

The progression of kyphotic deformity occurs in the first months and stabilizes thereafter (22). Although a similar correction grade was found in all studies, without any correlation with the length of instrumentation, patients with SS stabilization experienced major progression in the follow-ups. Moreover, loss of progression above 10°, associated with SS instrumentation, has been noted by several authors in the literature (7, 8, 20, 23, 24). The LS stabilization allows a longer lever to correct kyphosis and facilitates strength distribution at more levels; incorporation of

hooks can also reduce the pull-out risk (23-26).

Kyphosis progression could be also responsible for chronic back pain due to alterations in the sagittal balance, which can cause muscle fatigue and pain (27). Nevertheless, Tezeren and Kuru (6) and Sapkas et al. (8) reported no significant differences in pain scores between the SS and LS groups. On the other hand, Lee et al. (7) found that the LS group had better mean Dennis pain scores, although it was not confirmed by the work status assessment scale. Other studies have demonstrated no significant relationship between kyphosis and back pain; therefore, no significant difference was reported between surgically and non-surgically treated patients (25, 28).

Instrumentation length is a risk factor for ASD, as demonstrated by Cheh et al. who recognized the importance of age and number of fused vertebrae. In their study, patients over the age of 50 years were at a higher risk of clinical ASD, compared to patients aged 50 years or less. Also, fusion up to L1-L3 levels increased the risk of ASD, compared with L4 and L5 (29). Bydon et al. recently published their experience with 511 cases of instrumented posterolateral arthrodesis. They showed that patients who had floating lumbar fusions were more likely to develop ASD in comparison with those who had lumbosacral fusions, involving the L5-S1 spinal segment (30).

The longer is the fused segment, the higher is the overload distributed onto the adjacent vertebrae (29, 30). Obviously, a more mobile lumbar spine is at a greater risk, compared to the thoracic spine. In fact, extending the instrumentation in the thoracic spine is not extremely problematic because of its intrinsic rigidity. On the other hand, in the lumbar spine, a stabilization, which is as short as possible, can be advocated, similar to cases where only L5-S1 disks are between the arthrodesis site and sacrum (26, 30).

To reduce the risk of ASD, instead of performing two-segment stabilization, several authors have suggested

monosegmental stabilization (31-33). It consists of fusion between the fractured vertebra and the proximal or distal vertebra if the lower or upper endplate is not involved in the fracture. Obviously, it cannot be applied in cases where the endplate is intact and it is possible to insert screws in the fractured vertebra.

Lee et al. (7) proposed SS instrumentation with prolonged bed rest for 10 - 14 days, showing a similar loss of correction to the LS group. Use of SS versus LS stabilization is problematic in spine surgeries not only for fracture, but also for other pathologies, such as degenerative diseases or scoliosis. Ha et al. focused on preoperative disc degeneration, as another factor which should be evaluated for selecting the fixation level (34). Moreover, Cho et al. in a study on scoliosis patients with SS and LS stabilization revealed the superiority of LS to SS stabilization for a better correction; however, as evidenced in patients with trauma and deformity, a better correction does not necessarily indicate a higher level of satisfaction in patients (35).

Considering the scarcity of evidence in the literature, it is not possible to confirm the superiority of LS over SS instrumentation in terms of the outcomes. In fact, this comparison may not be possible in future studies either due to the diversity of variables which need to be considered, such as patients' characteristics, comorbidities, age, fracture level, condition of adjacent segments, and functional demand. The effectiveness of LS instrumentation in reducing the loss of correction after surgery can be sustained in cases of thoracolumbar fracture. Nevertheless, further prospective randomized studies with proper methodologies are necessary.

Footnote

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