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Unstable Thoracolumbar Injuries: Factors Affecting the Decision for Short-Segment vs Long-Segment Posterior Fixation

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ABSTRACT

Background: Factors influencing the length of spinal instrumentation have been mostly evaluated in burst fractures, receiving more attention than other unstable thoracolumbar injuries. We aimed to evaluate clinical factors affecting surgical decision-making and associated complications.

Methods: This was a multicentric retrospective cohort study. Outcomes of patients with AO Spine injury classification types B2, B3, and C operated through an open posterior-only approach were analyzed. Length of instrumentation was correlated with age, type of injury, comorbidities, level of injury, neurological status, and complications.

Results: Among 439 patients, 30.3% underwent short-segment fixation (SSF) and 69.7% underwent long-segment fixation (LSF). Type C injuries were treated with LSF in 89.4% of cases ($P < 0.001$). On multivariate analysis, age ≤39 years (OR: 2.06), AO spine type B2 (OR: 3.58), and type B3 (OR: 7.48) were statistically significant predictors for SSF, while hypertension (OR: 4.07), upper thoracic injury (OR: 9.48), midthoracic injury (OR: 6.06), and American Spinal Injury Association Impairment Scale A (OR: 3.14) were significantly associated with LSF. Patients with SSF had fewer overall complications (27.1% vs 50.9%, $P < 0.001$) and were less likely to develop pneumonia (6.0% vs 18.3%, $P < 0.001$) and urinary tract infections (6.8% vs 16.3%, $P < 0.007$).

Conclusions: Unstable thoracolumbar injuries were mostly treated by LSF. Length of instrumentation was affected by the type of spinal injury, location of the injury, and neurological status. SSF was associated with lower rates of early complications than LSF.

Clinical Relevance: The decision on the length of fixation in the surgical treatment of unstable thoracolumbar injuries is affected by different factors, and it will impact the rate of postoperative complications.

Level of Evidence: 3.

Complications

Keywords: spinal injuries, multivariate analysis, pedicle screws, postoperative complications, spinal fusion

INTRODUCTION

Unstable thoracolumbar injuries benefit from surgical treatment, even in patients with multiple trauma, achieving early mobilization, neurological recovery, and a lower complication rate.[1] AO Spine fracture types B2, B3, and C have an increased level of biomechanical instability, where distraction, rotational, and/or translational components may be present.[2] Therefore, in spite of neurologic status, these types of fractures are always considered surgical.[3]

For these unstable injuries, the timing of the surgery has been associated with outcomes[4] and complication rates.[5] As these injuries are considered highly unstable—in particular, AO spine type C—the trend among spine surgeons is to perform longer fixations, including more than one segment above and below the fracture, which is a known factor associated with longer surgical time and increased blood loss, morbidity, and cost.[6]

The length of fixation has been mostly studied in thoracolumbar burst fractures (AO spine type A) through biomechanical analysis and clinical outcome studies.[7–9] For thoracolumbar burst fractures, short constructs generally provide enough stability with less surgical morbidity than longer constructions and with similar clinical and radiological outcomes.[10] However, long constructions are more likely to correct spinal deformities and residual kyphosis, with the counterpoint of having more functional spinal segments involved.[11] Therefore, the aim of this study is to compare the clinical factors that affect the surgical decision of the length of the construct and the association with early postoperative complications.

METHODS

Study Design

The study was designed and open to AO Spine members and their respective centers. This study was conducted in accordance with ethical standards and approved by ethics committees (IRB number: 29857420.0.1001.5342) at all participating centers.

Data Collection

Patients aged 18 years or older who underwent open posterior instrumentation due to AO Spine types B2, B3, and C thoracolumbar injuries from January 2014 to December 2019 were included in the analysis. Demographic variables, type of injury (AO Spine classification), level of the injury, comorbidities, neurological status (American Spinal Injury Association [ASIA] Impairment Scale [AIS]), and postoperative complications were obtained from the medical records.

In the case of multiple lesions, patients were classified using the highest lesion for both injury type and level of injury.

The extent of instrumentation was divided between short-segment fixation (SSF) and long-segment fixation (LSF). SSF was defined as one segment above and below the injury, regardless of the inclusion of the injured segment. LSF was defined as 2 or more segments above and below the injury. The decision to perform SSF or LSF was made by each surgeon based on their experience and criteria. The variables that may have influenced these decisions were studied using multivariable analysis.

Definitions

Medical instability: Patients who on admission presented with respiratory and/or hemodynamic instability or other organ failures that needed urgent attention and thus had surgical treatment delayed.

Implant availability: Some included centers do not have immediate availability of spinal implants, which can delay surgical treatment even under optimal conditions.

Level of injury: The level of spinal injury was divided into 4 categories, considering the uppermost injured vertebra, as follows: upper thoracic: from T1 to T5, midthoracic: T6 to T9, thoracolumbar: T10 to L2, and lumbar: L3 to L5.

AO Spine Classification

The AO Spine thoracolumbar spinal injury classification system describes 3 main morphological patterns of injury: type A, consisting of vertebral body compression fractures; type B, in which there is a posterior tension band disruption; and type C, in which there is a translation injury.[12] While the optimal treatment of type A fractures varies from nonsurgical to different surgical approaches, in this study, we analyzed noncompression injuries (types B and C), in which there is consensus on their surgical management.

Statistical Analysis

For continuous variables, the Shapiro-Wilk test was performed to determine whether they were normally or non-normally distributed across the overall patient sample. All variables of interest were found to have a non-normal distribution. Therefore, continuous variables were dichotomized, using the median as the cutoff value, such as 39 years of age (≤39 or >39). For intergroup comparisons of categorical variables, Pearson χ^2 analysis and Fisher's exact test were employed as appropriate. ORs and 95% CIs were calculated for each variable in terms of the variable's impact on the decision of length of the construct.

Multivariable analyses were performed to identify baseline and preoperative factors associated with SSF vs LSF by binary logistic regression analysis. For each model, independent variables were introduced into the model by forward entry and retained in the final model when $P < 0.1$. Data were exported for analysis into the statistical software program SPSS version 25 for Mac (IBM, Armonk, NY). A two-tailed P value of <0.05 was considered statistically significant.

RESULTS

There were 439 patients included in the analysis. The mean age was 39.4 ± 15.7 years. Three hundred and twenty-four patients (73.8%) were men; 259 patients had an AO Spine type B injury and 180 had a type C.

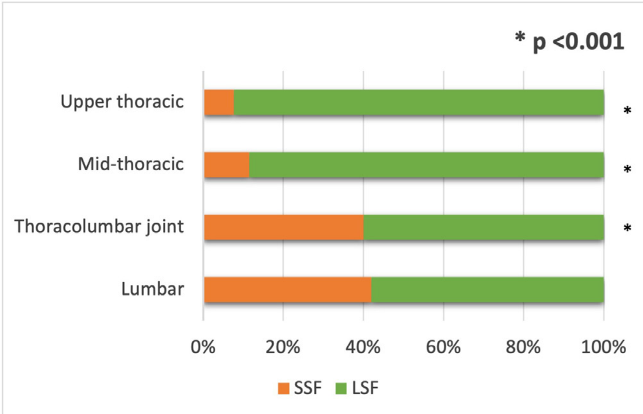

Figure. Distribution of patients receiving short-segment fixation (SSF) or long-segment fixation (LSF) according to the level of injury.

The thoracolumbar spine was the most frequent site of injury (60.4%), and 125 patients (28.5%) were AIS A and 227 patients were (51.7%) AIS E.

Short-Segment vs Long-Segment Fixation

A total of 113 patients (30.3%) underwent SSF, while 306 patients (69.7%) underwent LSF. There were no significant differences between both groups in terms of age, gender, obesity, and smoking status. SSF was more frequently performed in B2 injuries, while LSF was in type C injuries. According to the level of injury, the upper thoracic and midthoracic levels were treated with LSF in 92.3% and 88.5%, respectively. Thoracolumbar injuries underwent SSF in 40% of the cases (Figure). A total of 92.8% of the AIS A patients were treated using LSF, while 56.8% of AIS E patients received LSF. Further details regarding patients treated using SSF or LSF are provided in Table 1.

Patients with AIS A were more frequently treated using LSF. However, there were 9 patients (7.2%) who were treated with SSF: 3 patients with injuries in the upper thoracic spine, 3 patients in the midthoracic spine, and 3 in the thoracolumbar junction. According to the AO spine classification, 4 of them were type B2 and 5 were type C; 5 of these 9 patients had preoperative medical instability, and 6 developed some postoperative complications.

Multivariate Analysis

On multivariate analysis by binary logistic regression, significant factors favoring SSF as length of construct were as follows: age ≤39 years (OR: 2.06, 95% CI: 1.26–3.37), AO spine type B2 (OR: 3.58, 95% CI: 1.82–7.02), and type B3 (OR: 7.48, 95% CI: 1.88–29.79); significant factors favoring LSF were hypertension (OR: 0.25, 95% CI:0.08–0.81), upper thoracic injury (OR: 0.11, 95% CI: 0.03–0.41), midthoracic injury (OR: 0.18, 95% CI: 0.06–0.56), and AIS A (OR: 0.32, 95% CI:0.13–0.78).

Multivariate analyses for direct calculation of OR and 95% CI for LSF was performed and were hypertension

Table 1. Clinical characteristics of patients with SSF vs LSF (*N* = 439).

Variable	*n* (%)	SSF (*n* = 133)	LSF (*n* = 306)	*P* Value
Age ≤39 y	233 (53.1%)	78 (58.6%)	155 (50.7%)	0.075
Men	324 (73.8%)	93 (69.9%)	231 (75.5%)	0.223
Public hospital	358 (81.5%)	101 (75.9%)	257 (83.9%)	0.046
Hypertension	33 (7.5%)	4 (3.0%)	29 (9.5%)	0.018
Diabetes mellitus	19 (4.3%)	5 (3.8%)	14 (4.6%)	0.699
Obesity	12 (2.7%)	5 (3.8%)	7 (2.3%)	0.282[a]
Smoker	35 (8.0%)	10 (7.5%)	25 (8.2%)	0.817
Preoperative medical instability	105 (23.9%)	16 (12.0%)	89 (29.1%)	<0.001
Implant's availability	82 (18.7%)	29 (21.8%)	53 (17.3%)	0.268
AO Spine injury				
B2	245 (55.8%)	107 (80.5%)	138 (45.1%)	<0.001
B3	14 (3.2%)	7 (5.3%)	7 (2.3%)	0.094[a]
C	180 (41.0%)	19 (14.3%)	161 (52.6%)	<0.001
Level of injury				
Upper thoracic	65 (14.8%)	5 (3.8%)	60 (19.6%)	<0.001
Midthoracic	78 (17.8%)	9 (6.8%)	69 (22.5%)	<0.001
Thoracolumbar	265 (60.4%)	106 (79.7%)	159 (51.9%)	<0.001
Lumbar	31 (7.1%)	13 (9.8%)	18 (5.9%)	0.144
Neurological status				
AIS A	125 (28.5%)	9 (6.8%)	116 (37.9%)	<0.001
AIS B	23 (5.2%)	4 (3.0%)	19 (6.2%)	0.167
AIS C	30 (6.8%)	8 (6.0%)	22 (7.2%)	0.654
AIS D	34 (7.7%)	14 (10.5%)	20 (6.5%)	0.151
AIS E	227 (51.7%)	98 (73.7%)	129 (42.2%)	<0.001

Abbreviations: AIS, ASIA Impairment Scale; ASIA, American Spinal Injury Association; LSF, long-segment fixation; SSF, short-segment fixation.
[a]Fisher's exact test.

Table 2. Univariate and multivariate logistic regression analysis for SSF.

Variable	Univariate		Multivariate	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age ≤39 y	0.72 (0.48–1.09)	0.075	1.72 (1.03–2.87)	0.038
Men	0.76 (0.48–1.19)	0.223		
Public hospital	0.60 (0.36–0.99)	0.046		
Hypertension	0.29 (0.10–0.86)	0.018	0.25 (0.08–0.81)	0.021
Diabetes mellitus	0.82 (0.29–2.31)	0.699		
Obesity	1.67 (0.52–5.36)	0.282		
Smoker	0.91 (0.43–1.96)	0.817		
Preoperative medical instability	0.33 (0.19–0.59)	<0.001		
Implant availability	1.33 (0.80–2.21)	0.268		
AO Spine injury				
B2	5.01 (3.09–8.13)	<0.001	3.54 (1.80–6.96)	<0.001
B3	2.37 (0.82–6.91)	0.094	9.41 (2.23–39.61)	0.002
C	0.15 (0.09–0.26)	<0.001		
Level of injury				
Upper thoracic	0.16 (0.06–0.41)	<0.001	0.11 (0.03–0.38)	0.001
Midthoracic	0.25 (0.12–0.52)	<0.001	0.17 (0.05–0.52)	0.002
Thoracolumbar	3.63 (2.25–5.86)	<0.001		
Lumbar	1.73 (0.82–3.65)	0.144		
Neurological status				
AIS A	0.12 (0.06–0.24)	<0.001	0.32 (0.13–0.78)	0.012
AIS B	0.47 (0.17–1.40)	0.167		
AIS C	0.83 (0.36–1.91)	0.654		
AIS D	1.68 (0.82–3.44)	0.151		
AIS E	3.84 (2.45–6.01)	<0.001		

Abbreviations: AIS, ASIA Impairment Scale; ASIA, American Spinal Injury Association; SSF, short-segment fixation;
[a]Fisher's exact test.

(OR: 4.07, 95% CI: 1.24–13.35), upper thoracic injury (OR: 9.48, 95% CI: 2.61–34.42), midthoracic injury (OR: 6.06, 95% CI: 1.92–19.08), and AIS A (OR: 3.14, 95% CI: 1.28–7.68) (same *P* values). More details of the univariate and multivariate analyses are shown in Table 2.

Complications

At least 1 complication was seen in 192 patients (43.7%); 27.1% of the patients from the SSF group and 50.9% from the LSF group ($P < 0.001$). Pneumonia (14.6%) and urinary tract infection (13.4%) were the most frequently observed complications and were significantly lower in the SSF group than in the LSF group (6.0% vs 18.3%, $P < 0.001$ and 6.8% vs 16.3%, $P < 0.0076$, respectively). There was no statistically significant difference between the groups in wound-related complications (Table 3).

Three patients died in the LSF group (ages 38, 58, and 65 years). All of them had type C injuries and AIS A, and 2 had preoperative medical instability. The first 2 patients developed pneumonia, and the third patient developed a pulmonary embolism. They died from those complications on postinjury days 28, 14, and 14.

Table 3. Complications reported according to SSF or LSF.

Variable	Total (*N* = 439)	SSF (*n* = 133)	LSF (*n* = 306)	*P* Value
Any complication	192 (43.7%)	36 (27.1%)	156 (50.9%)	<0.001
Pneumonia	64 (14.6%)	8 (6.0%)	56 (18.3%)	0.001
Urinary tract infection	59 (13.4%)	9 (6.8%)	50 (16.3%)	0.007
Deep vein thrombosis	8 (1.8%)	0 (0%)	8 (2.6%)	0.054[a]
Pulmonary thromboembolism	3 (0.7%)	0 (0%)	3 (1.0%)	0.338[a]
Postoperative hematoma	4 (0.9%)	0 (0%)	4 (1.3%)	0.235[a]
Cerebrospinal fluid leak	7 (1.6%)	1 (0.8%)	6 (2.0%)	0.321
Wound infection	35 (8.0%)	8 (6.0%)	27 (8.8%)	0.318
Wound dehiscence	17 (3.9%)	2 (1.5%)	15 (4.9%)	0.09
Neurological impairment	1 (0.2%)	0 (0%)	1 (0.3%)	0.697[a]
Reintervention	24 (5.5%)	5 (3.8%)	19 (6.2%)	0.299
Mortality	3 (0.7%)	0 (0%)	3 (1.0%)	0.338[a]

Abbreviations: LSF, long-segment fixation; SSF, short-segment fixation.
[a]Fisher's exact test.

DISCUSSION

Unstable spinal injuries are generally treated with long-segment instrumented constructions to avoid mechanical failure due to spinal load.[13] However, as far as we know, there are no randomized prospective studies evaluating the benefits of SSF vs LSF for these injuries. Consequently, we designed this retrospective study to analyze clinical factors that might influence a surgeon's decision to perform SSF vs LSF and evaluate the related complications to this treatment chosen in unstable injuries.

AO Spine has simplified the understanding of the degree of instability of thoracolumbar injuries, and subsequent treatment, with universal acceptance,[14] and it is well known that LSF offers a higher capability to restore stability and spinal alignment, which can be especially useful to prevent progression of posttraumatic spinal deformity with neurological deficit.[4] Different extensions of constructions are found in literature, with or without associated anterior constructions.[15] We found independent factors for the use of LSF in the upper thoracic and midthoracic fractures, as has been previously recommended.[16] This observation could be explained due to the tendency of not stopping an end of construct in the apex of the thoracic kyphosis, to reduce the risk of proximal junctional kyphosis emphasized when reduction of kyphotic deformity has been performed.[17]

For burst fractures, with a more homogeneous spinal injury pattern, a short fixation is generally sufficient, providing spinal stability without the need for more extensive instrumentation and avoiding the inclusion of functional and healthy spinal segments.[18] Instrumentation of the fractured level in the construction has also the advantage of providing similar biomechanical strength than a circumferential procedure in type A injuries and avoiding the need for an anterior approach, which may add morbidity.[19] Moreover, conservative management has a role in neurologically intact patients.[20] Of note, for more unstable injury patterns—such as types B2, B3, and C injuries—the indications for short vs long instrumentations have yet to be determined. In fact, in B2 injuries, different degrees of neurological status influence the decision of surgical treatment among regions.[14] Interestingly, in the present study, AIS A was an independent predicting factor for the decision of LSF constructions.

Considering our results, other significant factors affecting the decision for SSF were type B fractures, while type C did not impact LSF on multivariate analysis. Tan et al[19] published their experience in AO spine type B1 and B2 injuries, preferring LSF with, on average, 4 levels fixated (range 2–7) to treat these lesions, while other authors have preferred SSF for type B injuries,[21] with known factors for developing mild loss of corrections in B2 injuries treated with SSF with intermediate screws.[22] Whereas for B3 injuries, generally associated with a rigid spine—such as DISH or Ankylosing spondylitis as M2 modifier of the AO Spine[23]—there were a similar number of SSF and LSF procedures performed in our study, probably due to the small number of patients included, despite the general knowledge that these injuries are considered as highly unstable requiring LSF.[24] Type C injuries include translation injuries, but it is not differentiated between a vertebral luxation and a vertebral fracture, explaining partially why it was not a predicting factor for LSF, whereas SSF has been recommended for C injuries in selected patients by other authors,[16,25] with similar clinical and radiological outcomes than LSF.[26]

Regarding complications, it is well known that severely injured patients and those with neurological deficits (especially, AIS A) have more complications, and polytraumatized patients also have a higher chance of death.[27] SSF has less blood loss and operative time while it saves fusion levels.[26] In our study, LSF was associated with higher rates of medical complications without a significant difference in wound-related complications. Pneumonia was the main complication seen, especially in the LSF group; this could be explained by the amount of upper thoracic and midthoracic injuries treated with longer constructs. However, imaging findings were not analyzed, and they are necessary to detect construct failure with loss of correction during follow-up.[16,22]

This study has several limitations. First, due to the retrospective and multicentric basis of this study, significant heterogeneity was expected among the participant spine centers; therefore, it did not allow for accurately collecting important clinical data regarding implants used and radiological parameters—local kyphotic angle, vertebral body height, and height of disc spaces—that influence the decision-making in thoracolumbar spinal trauma. Second, surgical treatment was decided on by the surgeon/center according to various other factors that we could not assess, like surgeon experience and preferences. Third, this analysis did not include any other frailty assessment tool, probably limiting the length of construct in highly medically vulnerable patients. All of the included cases were open posterior approaches, additional surgical treatment such as corpectomy plus SSF were not compared, and the instrumentation of the index level was not provided.

Finally, for the analysis, the patients were categorized according to the highest level of injury, not considering a concomitant AO Spine type A fracture of the index vertebrae and the comminution degree that affect the decision of length of the construct.

CONCLUSIONS

Unstable thoracolumbar injuries were treated preferably using LSF. The length of instrumentation was affected by the type of AO spine injury, location of the injury, and neurological status. SSF was associated with lower rates of early complications than LSF. Many clinical and radiological outcomes were not addressed in this study and hence require further studies.

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