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Kristen Radcliff
Rothman Institute, Thomas Jefferson University

Christopher K Kepler
Rothman Institute, Thomas Jefferson University

Todd A Rubin
Thomas Jefferson University

Motasem Maaieh
Rothman Institute

Alan S Hilibrand
Rothman Institute, Thomas Jefferson University

See next page for additional authors

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Authors

Kristen Radcliff, Christopher K Kepler, Todd A Rubin, Motasem Maaieh, Alan S Hilibrand, James Harrop, Jeffrey A Rihn, Todd J Albert, and Alexander R Vaccaro

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Does the load-sharing classification predict ligamentous injury, neurological injury, and the need for surgery in patients with thoracolumbar burst fractures?

Clinical article

Kristen Radcliff, M.D.,[1,3] Christopher K. Kepler, M.D., M.B.A.,[1,3] Todd A. Rubin, M.D.,[1] Motasem Maaieh, M.D.,[3] Alan S. Hilibrand, M.D.,[1,3] James Harrop, M.D.,[2] Jeffrey A. Rihn, M.D.,[1,3] Todd J. Albert, M.D.,[1,3] and Alexander R. Vaccaro, M.D., Ph.D.[1,3]

Departments of [1]Orthopaedic Surgery and [2]Neurological Surgery, Thomas Jefferson University; and [3]Rothman Institute, Philadelphia, Pennsylvania

Object. The load-sharing score (LSS) of vertebral body comminution is predictive of results after short-segment posterior instrumentation of thoracolumbar burst fractures. Some authors have posited that an LSS > 6 is predictive of neurological injury, ligamentous injury, and the need for surgical intervention. However, the authors of the present study hypothesized that the LSS does not predict ligamentous or neurological injury.

Methods. The prospectively collected spinal cord injury database from a single institution was queried for thoracolumbar burst fractures. Study inclusion criteria were acute (< 24 hours) burst fractures between T-10 and L-2 with preoperative CT and MRI. Flexion-distraction injuries and pathological fractures were excluded. Four experienced spine surgeons determined the LSS and posterior ligamentous complex (PLC) integrity. Neurological status was assessed from a review of the medical records.

Results. Forty-four patients were included in the study. There were 4 patients for whom all observers assigned an LSS > 6, recommending operative treatment. Eleven patients had LSSs ≤ 6 across all observers, suggesting that nonoperative treatment would be appropriate. There was moderate interobserver agreement (0.43) for the overall LSS and fair agreement (0.24) for an LSS > 6. Correlations between the LSS and the PLC score averaged 0.18 across all observers (range –0.02 to 0.34, p value range 0.02–0.89). Correlations between the LSS and the American Spinal Injury Association motor score averaged –0.12 across all observers (range –0.25 to –0.03, p value range 0.1–0.87). Correlations describing the relationship between an LSS > 6 and the treating physician's decision to operate averaged 0.17 across all observers (range 0.11–0.24, p value range 0.12–0.47).

Conclusions. The LSS does not uniformly correlate with the PLC injury, neurological status, or empirical clinical decision making. The LSSs of only one observer correlated significantly with PLC injury. There were no significant correlations between the LSS as determined by any observer and neurological status or clinical decision making. *(http://thejns.org/doi/abs/10.3171/2012.3.SPINE11570)*

Key Words • thoracolumbar burst fracture • load-sharing score • load-sharing classification • posterior ligamentous complex • trauma

The load-sharing classification was initially proposed to predict the outcome following short-segment posterior instrumentation in the treatment of thoracolumbar burst fractures.[17,19] The LSC quantifies the amount of vertebral body damage to predict the ability of the vertebral body to support axial loading after burst fractures. It was initially designed to distinguish which fractures require either long-segment instrumentation or anterior column support once the decision to operate has been made. Several elements are incorporated into this classification system, including vertebral comminution, fragment diastasis, and degree of kyphosis. The LSC has demonstrated adequate inter- and intraobserver reliability[6–10,19] in predicting the need for short- versus long-segment stabilization. An LSS > 6 out of 9 possible points has been shown to be predictive of construct failure of short-segment posterior instrumentation, suggesting that these fractures are best treated with a combined anterior-posterior approach or long-segment posterior fixation.[3,7,8,10,17,19,29,30]

Abbreviations used in this paper: ASIA = American Spinal Injury Association; LSC = load-sharing classification; LSS = load-sharing score; PLC = posterior ligamentous complex.

Although increased vertebral body damage, as reflected by comminution, fragment diastasis, and kyphosis, may be associated with a greater energy of injury, there are other factors, such as posterior ligamentous complex injury and neurological injury, that are important in surgical decision making. Posterior ligamentous complex injury is recognized as an important factor in determining fracture stability.[12,18,26,31] Failure to appreciate ligamentous injuries may result in late deformity if the affected segments are not sufficiently stabilized.[18] The neurological status of the patient also predicts the need to surgically address such fractures. The LSC does not directly assess ligamentous injury or neurological status, both of which are important determinants of the need for surgical intervention. The fact that the LSC does not directly include neurological status and the integrity of ligamentous structures may impair its utility as a standalone surgical decision-making instrument. Nonetheless, the LSC has been used in this manner to make decisions regarding the operative versus nonoperative management of thoracolumbar burst fractures.[1,2,7]

The purpose of this study was to evaluate the LSSs in a population of patients with thoracolumbar fractures to see how well the scores correlated with neurological status, PLC status, and treatment decisions. It was hypothesized that an LSS > 6 would not have a significant correlation with the need for surgery, patient neurological status, or PLC injury.

Methods

After obtaining institutional review board approval, we identified consecutive thoracolumbar fractures (T-10 to L-2) treated at our institution in the time period from 2006 to 2009. Patients were included in our analysis if they had acute, traumatic thoracolumbar (T10–L2) burst fractures that had occurred within 24 hours of presentation. Patients who received both operative and nonoperative treatments were included in the study as well. Treating physicians did not serve as observers in the study. The patients excluded from study were those who had flexion-distraction injuries, infections, tumors, previous spine surgery, or pathological fractures. Demographic characteristics were collected from a review of the medical records to compose a clinical vignette accompanied by midsagittal CT cuts, axial CT cuts at the level of the pedicle, and coronal CT scans through the vertebral body. The vignette did not provide neurological status or MR images. Based on this vignette, the LSS was determined by 4 fellowship-trained spine surgeons using the methodology initially described by McCormack et al.[17] These 4 spine surgeons who acted as observers did not participate in the initial care of patients included in the study.

Posterior ligamentous complex vignettes were similarly created to provide a brief history along with midsagittal T1-, midsagittal T2-, and axial T2-weighted MR images at the level of the pedicles. No neurological status or mechanism of injury was provided. Observers evaluated the PLC to assess the integrity of the intervertebral disc, supraspinous ligament, interspinous ligament, ligamentum flavum, and facet joints. The order of cases was altered, and evaluation of the MRI components was conducted 2 months after the initial CT-based LSS scoring. Injury to the PLC was defined as intact, indeterminate, or disrupted based on the criteria of Haba et al.[11] and as a discontinuity or nonvisualization of the black stripe representing the supraspinous ligament on sagittal T1- and/or T2-weighted images together with high signal intensity of the interspinous space on sagittal T2-weighted images. Posterior ligamentous complex integrity was scored using a previously described classification:[27] 0 points for intact, 2 points for indeterminate, or 3 points for disrupted. Posterior ligamentous complex scores from the 4 observers were compiled into a composite score equal to the mode of the score assigned by the 4 observers, with ties (2 of 44 cases) broken through expert adjudication by the senior author (A.R.V). Neurological status was assessed based on consensus review of the consulting orthopedic, neurosurgical, and physiatric examinations and is represented by both the ASIA motor score[16] and the Frankel grade.[5]

Statistics were calculated using SPSS 18.0 (SPSS, Inc.). Interobserver reliability was evaluated for this nonparametric data using the Cohen kappa across all pair combinations of observers, and kappa analysis was used for evaluating concordance of LSSs > 6. The average value of the Cohen kappa was calculated as the mean kappa agreement between all potential observer combinations. Kappa values were graded according to a previously described semi-quantitative scale:[14] no agreement for values < 0, slight agreement for 0–0.20, fair agreement for 0.21–0.40, moderate agreement for 0.41–0.60, substantial agreement for 0.61–0.80, and near perfect agreement for 0.81–1.0. Correlation between the LSS and the ASIA motor score, Frankel grade, and PLC score was analyzed using the Spearman rank-order test. Statistical significance was assumed for a p value < 0.05.

Results

We identified 53 consecutive patients who had burst fractures at the thoracolumbar junction (defined as between T-10 and L-2) during a 4-year period from 2006 to 2009. Six patients were excluded from our analysis because of inadequate imaging studies, and 3 additional patients were excluded because they did not meet study inclusion criteria (1 pathological fracture and 2 nonacute fractures). Therefore, 44 patients were included in the study.

Demographic and injury characteristics are listed in Table 1 for the remaining 44 patients. Twenty-two males and 22 females had a mean age of 42.9 years. The most common level of injury was L-1, which represented 61% of the injuries. The most common neurological injury pattern was ASIA Grade C (43%), followed by ASIA Grade E (30%). Twenty-five of the patients (57%) were treated with operative stabilization. The mean ASIA motor score was 83.0.

Summary scores for the LSS are listed in Table 2. The mean LSS was 6.0 ± 1.48 (mean ± SD). Across the 4 observers, 18 patients on average had an LSS above the threshold score of 6, which has been used in other studies to indicate the need for operative intervention.[1,2,7]

TABLE 1: Summary of demographic and injury characteristics for 44 patients with burst fractures at the thoracolumbar junction*

Characteristic	Value
M/F	22/22
mean age in yrs	42.9
level of injury	
T-10	1
T-11	5
T-12	9
L-1	27
L-2	2
ASIA grade (no. of patients)	
A	9
B	1
C	19
D	2
E	13
average ASIA motor score	83
% patients surgically treated	57
injury mechanism (no. of patients)	
fall	23
MVA	19
other	2

* MVA = motor vehicle accident.

Interobserver Agreement

Gross interobserver agreement is listed in aggregate form in Table 3. Of the 44 patients, 15 had consensus treatment decisions. There were 4 patients in whom all observers determined an LSS > 6, recommending operative treatment. There were 11 patients with an LSS ≤ 6 according to all observers, consistent with nonoperative treatment. The average value of the Cohen kappa was 0.43, representing moderate agreement. The kappa statistic describing agreement between observers for an LSS > 6 was 0.24, representing fair agreement.

Correlations of LSS with the decision to operate, ASIA motor score, Frankel grade, and PLC injury score are presented in Table 4.

Correlation Between LSS and PLC Injury

The Spearman correlation coefficient describing the relationship between the LSS and the PLC Injury score averaged 0.18 across all observers and ranged from −0.02 to 0.34 (p value range 0.02–0.89), with one observer obtaining a statistically significant correlation between LSS and the presence of a PLC injury.

TABLE 2: Average LSS according to observer

Observer	Average LSS	Standard Deviation	No. of Patients w/ LSS >6
1	6.2	1.5	19
2	7.2	1.5	33
3	4.8	1.4	7
4	5.8	1.5	14
average	6.0	1.48	18

TABLE 3: Gross interobserver agreement

Treatment Decision	No. of Patients
consensus operate (LSC >6)	4
consensus nonoperative (LSC ≤6)	11
LSC disagreement	29

Correlation Between LSS and Neurological Injury

The Spearman correlation coefficient between the LSS and the ASIA motor score averaged −0.12 across all observers and ranged from −0.25 to −0.03 (p value range 0.1–0.87), demonstrating no significant relationships.

Correlation Between LSS and Clinical Decision Making

The Spearman correlation coefficient describing the relationship between an LSS > 6 and the decision of the treating physician to operate averaged 0.17 across all observers and ranged from 0.11 to 0.24 (p value range 0.12–0.47), demonstrating no significant relationships.

Patient Outcome

Of the 4 patients who the observers determined should undergo operative treatment as a result of a consensus LSS > 6, all underwent operative stabilization. Of the 11 patients whom the observers determined by consensus were candidates for nonoperative treatment, 8 were treated nonoperatively and 3 underwent surgery. None of the 11 patients who were treated nonoperatively, including the 8 who by consensus received nonsurgical treatment, required late stabilization because of progressive deformity, nonunion, or late neurological deficits. Finally, of the 29 patients with no consensus treatment decision by the observers, 17 underwent operative treatment while the remaining 12 patients were treated nonoperatively.

Discussion

Our results indicate that the LSS does not correlate with PLC injury, neurological status, or empirical clinical decision making. The LSS of only 1 of the 4 observers

TABLE 4: Correlation analysis of LSS with clinical parameters

	Spearman Rank Correlation (p value) of LSS w/			
Observer	Need for Op	ASIA Motor Score	Frankel Grade	PLC Injury Score
1	0.11 (0.47)	−0.25 (0.10)	−0.17 (0.28)	0.27 (0.08)
2	0.24 (0.12)	−0.09 (0.58)	0.08 (0.59)	−0.02 (0.89)
3	0.13 (0.41)	−0.03 (0.87)	−0.05 (0.75)	0.34 (0.02)
4	0.20 (0.19)	−0.12 (0.43)	−0.02 (0.89)	0.12 (0.46)
average	0.17	−0.12	−0.04	0.18

correlated significantly with PLC injury. There were no significant correlations between the LSS from any observer and neurological status or clinical decision making.

Agreement on the LSS between observers was moderate (average Cohen kappa between observer pairs 0.43) and less than the previously published value (0.79).[10] Agreement on an LSS > 6 between observers was less than for overall agreement on LSS at 0.24.

Limitations of this study include its retrospective nature and the high number of operative cases. It is possible that the study population included a higher percentage of acute severe cases, which may have biased the reviewers.

Other limitations include the possibility for error in assessing PLC injury or neurological injury. The PLC status was assessed based only on MRI findings. It was not possible to include intraoperative confirmation on all patients because 43% of them were treated conservatively.

Furthermore, we acknowledge that one possible explanation for the poor correlation between an LSS > 6 and empirical treatment may be erroneous clinical decision making. However, the operative decision making reflects the decisions made by the treating orthopedic surgeons and neurosurgeons in the period from 2006 to 2009. There is no single classification system that was universally used for surgical decision making during our study period, although several of us were involved in the development of a thoracolumbar injury classification system.[4,15,20–25,28,32] The operative indications in the present study therefore reflect a combination of detailed knowledge of the literature, assessments of neurological status and PLC integrity, and the clinical experience of spinal surgeons at a center with a high trauma volume.

Dai et al.[7] proposed using the LSC not only for the prediction of anterior column failure after short-segment posterior fixation, as was intended, but also for guidance in decisions about whether to pursue surgical versus nonsurgical treatment at initial presentation. While data in the present study support earlier work[10] validating the interobserver reliability of the LSC, the low interobserver consistency in assigning an LSS > 6 is concerning. Of the 44 patients included in our study, the 4 observers would have reached a consensus on treatment in only 15 cases by using the proposed threshold score of 6, with differing opinions regarding the need for surgery in the other 29 patients (Table 3). There was concordance between actual treatment decisions and consensus observer decisions in 12 (80%) of 15 patients; the LSC may be more reliable in clear-cut cases, but such cases represented the minority of fractures. Additionally, there was no significant correlation between an LSS > 6 and patients treated operatively for any observer. It is possible that this finding is the result of a repeated history of inappropriate treatment of these patients at our institution. A more likely explanation is that the LSC does not consider variables that are important to surgeons when selecting operative versus nonoperative management, such as neurological status and PLC integrity. This second explanation is supported by the low correlations describing the relationship between LSS and variables representing ASIA motor scores, Frankel grades, and PLC scores (Table 4). Further support for the inadequacy of the LSC as an indications instrument is the selection, by a panel of spine trauma experts, of neurological status and PLC integrity as factors important in surgical decision making,[28] although dissenting opinions about the importance of the PLC have been voiced.[6]

We acknowledge the value of the LSC in determining the need for anterior column support or long-segment posterior instrumentation in severe thoracolumbar burst fractures. Extension of the LSC to operative decision making may be appropriate if the instrument is used alongside the evaluation of PLC integrity and/or neurological status. Some authors[2,13] have described using the LSC to make treatment decisions while also considering neurological status and the Gertzbein classification, which grades mechanical instability. This seems a more appropriate use of the LSC, although the combination of disparate classification systems makes the approach described by Aligizakis et al.[2] somewhat cumbersome.

Conclusions

In summary, the LSC is not an appropriate test for stand-alone use in deciding whether to operate in cases of thoracolumbar burst fractures. The LSS demonstrated no significant correlation with neurological status or ligamentous injury, which may lead to inappropriate triage if treatment is based on the LSC alone. Furthermore, the LSS demonstrated low interobserver reliability for the proposed surgical treatment threshold score of 6, which may hinder communication and continuity of care among providers. To be effective and safe, surgical decision-making instruments must be reproducible, sensitive, and specific to accurately discern who will and will not benefit from surgery. This analysis suggests that surgical decision making for thoracolumbar burst fractures based solely on an LSS > 6 accomplishes none of these 3 objectives.

Disclosure

Dr. Vaccaro is a consultant for Gerson Lehrman Group, Guidepoint Global, and MedaCorp; has direct stock ownership in Replication Medical, Globus, K-2 Medical, Paradigm Spine, Stout Medical, Spine Medica, Computational Biodynamics, Progressive Spinal Technologies, Spinology, Orthovita, Vertiflex, Small Bone Innovations, Disk Motion Technology, NeuCore, Cross Current, Syndicom, In Vivo, Flagship Surgical, Advanced Spinal Intellectual Properties, Cytonics, Bonovo Orthopaedics, Electrolux, Gamma Spine, Location Based Intelligence, FlowPharma, and R.I.S.; holds patents with DePuy, Medtronic, Stryker Spine, Biomet Spine, Globus, Aesculap, and Nuvasive; and has received educational grants from Stryker Spine and Cerapedics. Dr. Harrop is a consultant for DePuy. Dr. Rihn has received support from DePuy Spine, Inc., for non–study related clinical research effort. Dr. Albert has received royalties for contribution from DePuy.

Author contributions to the study and manuscript preparation include the following. Conception and design: Radcliff, Kepler, Rubin, Albert, Vaccaro. Acquisition of data: Radcliff, Kepler, Rubin, Maaieh. Analysis and interpretation of data: Radcliff, Kepler, Maaieh, Hilibrand, Harrop. Drafting the article: Radcliff, Kepler, Rubin. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Radcliff. Statistical analysis: Kepler. Study supervision: Harrop, Albert, Vaccaro.

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Address correspondence to: Kris Radcliff, M.D., Department of Orthopedic Surgery, Rothman Institute, Thomas Jefferson University, 2500 English Creek Avenue, Egg Harbor Township, New Jersey 08422. email: kris.radcliff@rothmaninstitute.com.