Operative and nonoperative adverse events in the management of traumatic fractures of the thoracolumbar spine: a systematic review

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Object. Thoracolumbar spine injuries are commonly encountered in patients with trauma, accounting for almost 90% of all spinal fractures. Thoracolumbar burst fractures comprise a high percentage of these traumatic fractures (45%), and approximately half of the patients with this injury pattern are neurologically intact. However, a debate over complication rates associated with operative versus nonoperative management of various thoracolumbar fracture morphologies is ongoing, particularly concerning those patients presenting without a neurological deficit.

Methods. A MEDLINE search for pertinent literature published between 1966 and December 2013 was conducted by 2 authors (G.G. and R.D.), who used 2 broad search terms to maximize the initial pool of manuscripts for screening. These terms were “operative lumbar spine adverse events” and “nonoperative lumbar spine adverse events.”

Results. In an advanced MEDLINE search of the term “operative lumbar spine adverse events” on January 8, 2014, 1459 results were obtained. In a search of “nonoperative lumbar spine adverse events,” 150 results were obtained. After a review of all abstracts for relevance to traumatic thoracolumbar spinal injuries, 62 abstracts were reviewed for the “operative” group and 21 abstracts were reviewed for the “nonoperative” group. A total of 14 manuscripts that met inclusion criteria for the operative group and 5 manuscripts that met criteria for the nonoperative group were included.

There were a total of 919 and 436 patients in the operative and nonoperative treatment groups, respectively. There were no statistically significant differences between the groups with respect to age, sex, and length of stay. The mean ages were 43.17 years in the operative and 34.68 years in the nonoperative groups. The majority of patients in both groups were Frankel Grade E (342 and 319 in operative and nonoperative groups, respectively). Among the studies that reported the data, the mean length of stay was 14 days in the operative group and 20.75 in the nonoperative group.

The incidence of all complications in the operative and nonoperative groups was 300 (32.6%) and 21 (4.8%), respectively ($p = 0.1065$). There was no significant difference between the 2 groups with respect to the incidence of pulmonary, thromboembolic, cardiac, and gastrointestinal complications. However, the incidence of infections (pneumonia, urinary tract infection, wound infection, and sepsis) was significantly higher in the operative group ($p = 0.000875$). The incidence of instrumentation failure and need for revision surgery was 4.35% (40 of 919), a significant morbidity, and an event unique to the operative category ($p = 0.00396$).

Conclusions. Due to the limited number of high-quality studies, conclusions related to complication rates of operative and nonoperative management of thoracolumbar traumatic injuries cannot be definitively made. Further prospective, randomized studies of operative versus nonoperative management of thoracolumbar and lumbar spine trauma, with standardized definitions of complications and matched patient cohorts, will aid in properly defining the risk-benefit ratio of surgery for thoracolumbar spine fractures.

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KEY WORDS • lumbar spine • thoracic spine • complications • trauma • thoracolumbar • nonoperative fracture

IN the trauma population, thoracolumbar spine injuries are frequently encountered, accounting for almost 90% of all spinal fractures.^{18,21,27,32} Of these fractures, tho-

racolumbar burst fractures comprise a significantly high percentage (45%). Fortunately, approximately half of the patients with this injury pattern are neurologically intact.²⁹ Recent multicenter, prospective cohort data suggest that early (defined as less than 24 hours) surgery of spinal fractures optimizes functional outcomes in those presenting

Abbreviations used in this paper: LOS = length of stay; VAS = visual analog scale.

with neurological impairment.²² However, a debate over optimal treatment with operative versus nonoperative management of various thoracolumbar fracture morphologies is ongoing. This management is of particular concern for patients presenting without a neurological deficit. Advocates of surgical intervention note that operative treatment offers superior stability during the initial phase of healing, which may result in a decreased incidence of kyphotic deformity compared with nonoperative management. Furthermore, increased mechanical stability and capitalizing on immediate neural decompression have been shown to translate into decreased pain, earlier ambulation, shorter hospital stays, and earlier return to work.¹⁶

Classification schemes have been used to aid in the management of thoracolumbar fractures, and also may serve in the future to make published surgical data more meaningful.³⁸ Randomized trials comparing operative to nonoperative management of thoracolumbar injuries in the neurologically intact patient are limited to burst fractures, and have found no immediate advantage of operative stabilization over bracing.⁴⁹

Nonoperative treatment principally involves immobilization of the affected region of the spine with an external orthosis, but also uses postural reduction, bed rest, and rehabilitation.¹⁶ Experience with nonoperative treatment of stable thoracolumbar spinal fractures with successful results is well documented.^{6,8,12,17,23,33,40,41,48}

There is a lack of consensus with regard to the ideal operative management of many thoracolumbar fracture patterns, because there are limited long-term data on outcomes and procedural complication rates. Therefore, a systematic review of the literature was conducted to compare the complication rates of operative and nonoperative management of these thoracolumbar burst (AO Type A3) pathological entities. Although previous systematic reviews^{16,45,47} have focused on functional outcomes, to our knowledge this is the only review in the literature with a primary emphasis on relative adverse event rates.

Methods

A MEDLINE search for pertinent literature published between 1966 and December 2013 was performed using 2 broad search terms to maximize the initial pool of manuscripts for screening. These terms were “operative lumbar spine adverse events” and “nonoperative lumbar spine adverse events,” as well as within the Medical Subject Heading (MeSH) terminology: “postoperative complications” and “neurosurgery:surgical procedure, operative.” Furthermore, articles were supplemented with known literature on the topic as well as reviews of articles in references.

Inclusion Criteria

Articles included were those already published or published online prior to print, written in English, and that involved only human subjects. Comparative case series, comparative cohort studies, clinical trials, meta-analyses, and systematic reviews were eligible for inclusion. Relevant papers were then selected by 2 of the authors (G.G. and R.D.) and articles of interest from the

respective bibliographies were identified, and then all of these articles were reviewed for inclusion by the remaining authors. The articles that were included all analyzed 1 or more variables described in the pertinent question; namely operative or nonoperative intervention for a lumbar or thoracolumbar fracture, including any thoracic stabilization crossing the thoracolumbar junction as well as articles containing adverse event data. Analyses that met these criteria were included for comparison with results. These references were reviewed in detail to confirm that no individual studies were duplicated in the final analysis.

Exclusion Criteria

Papers that were excluded were laboratory or animal research studies, non-English publications, case studies, commentaries, noncomparative and descriptive studies, technical notes, and those articles deemed to be irrelevant to the study topics of interest by 2 authors (G.G. and R.D.). Relevant manuscripts that appeared in both searches were included in both groups for analysis if they were comparative studies.

Treatment Outcomes

The primary outcome of interest was the overall incidence of adverse events. Secondary outcomes were the reported rates of thromboembolic, infectious, pulmonary, cardiac, and gastrointestinal adverse events. Other secondary outcomes included the incidence of technical adverse events such as durotomy, CSF leak, new or worse neurological deficits, and instrumentation failure. Studies that met these criteria were included in the final analysis.

Data Analysis

Grading of articles on quality of evidence was done via the Oxford Center for Evidence-Based Medicine ranking criteria.²⁵ Data extracted were confirmed by 2 authors (G.G. and R.D.) on an independent basis. A proprietary software package was used for statistical analysis (“R” version 3.0.2, the R Foundation for Statistical Computing). A generalized mixed model controlling for random effect was used. A mixed logistic regression model was used for gender comparisons as well as for age comparisons.

Results

In an advanced MEDLINE search of the term “operative lumbar spine adverse events” on January 8, 2014, 1459 results were obtained. In a search of “nonoperative lumbar spine adverse events,” 150 results were obtained. After a review of all abstracts for relevance to traumatic thoracolumbar spinal injuries, 62 abstracts were reviewed for the “operative” group and 21 abstracts were reviewed in the “nonoperative” group (Fig. 1). A total of 14 manuscripts met inclusion criteria for the operative group and 5 manuscripts met criteria for the nonoperative group, and were included (Table 1).

There were a total of 919 and 436 patients in the operative and nonoperative treatment groups, respectively (Table 2). There were no statistically significant differences between the groups with respect to age, sex, and

Review of adverse events in managing thoracolumbar fractures

FIG. 1. Flow chart showing manuscript review process.

length of stay (LOS). The mean ages were 43.2 years in the operative and 34.7 years in the nonoperative groups. The majority of patients in both groups were neurologically intact (342 and 319 in operative and nonoperative groups, respectively). Among the studies that reported the data, the mean LOS was 14 days in the operative group and 20.75 in the nonoperative group.

The incidence of all complications in the operative and nonoperative groups was 300 (32.6%) and 21 (4.8%), respectively, which was not significant ($p = 0.1065$) (Table 3). There was no significant difference between the 2 groups with respect to the incidence of pulmonary, thromboembolic, cardiac, and gastrointestinal complications. However, the incidence of infection (pneumonia, urinary tract infection, wound infection, and sepsis) was significantly higher in the operative group ($p = 0.0009$). The incidence of instrumentation failure and need for revision surgery was 4.35% (40 of 919), a significant morbidity, and an event obviously unique to the operative category ($p = 0.004$).

Discussion

Treatment of lumbar and thoracolumbar traumatic spine fractures carries the potential for significant morbidity no matter which management scheme is used. Both operative and nonoperative modalities have been illustrated to have significant adverse events, and this is despite the relatively young age of patients in the operative and nonoperative groups (43 and 34 years, respectively).

Operative Versus Nonoperative Management of Thoracolumbar Burst Fractures

Several studies have suggested superiority of either operative or nonoperative management of thoracolumbar fractures.^{4,15,20,27,35,39,40} Specifically, 1 retrospective cohort study¹⁹ comparing operative to nonoperative management

concluded that surgery is superior, for its ability to provide an early return to full-time work. However, the lack of high-quality evidence-based literature makes these conclusions uncertain.

Of the approximately 1500 abstracts reviewed, there was only 1 Level I study, a randomized trial by Wood and colleagues⁴⁹ comparing operative treatment of thoracolumbar burst fractures to bracing in the neurologically intact patient. They found equivalence between the 2 groups with regard to functional outcome. These findings by Wood et al. were corroborated by Abudou and colleagues.¹ In a Cochrane review of operative versus nonoperative outcomes of burst fractures without neurological deficit, it was concluded that there was inadequate evidence to support the surgical treatment of burst fractures with the goal of limiting pain and improving functional outcome. Shen and colleagues provide further support for Wood's conclusions with equivocal results of a prospective study comparing nonoperative treatment (brace) to short-segment fixation for thoracolumbar junction fractures.⁴⁰ In this study, despite superior kyphosis correction (4°) and earlier pain relief in favor of surgery, no difference in functional outcome was noted at a 2-year follow-up. Bailey and coinvestigators conducted a randomized multicenter study to compare the effects of bracing on functional outcome in thoracolumbar burst fractures (AO Type A3).⁵ In the absence of posterior ligamentous complex disruption on imaging, and obvious comorbidity, the coinvestigators concluded that the inherent stability of burst fractures meant that there was no additional benefit to spinal stability provided by bracing. The aforementioned studies lend further credit to the belief that burst fractures are stable injuries in the absence of posterior ligamentous complex injury. To date, numerous studies report equivalence between surgery and orthosis, or report "good" functional outcomes by orthosis alone for thoracolumbar burst fractures.^{2,3,12,13,26–28,30,33,37,40,41,46,48,49}

However, contradictory conclusions were later reported. Siebenga and colleagues⁴² followed up prior equivocal studies with a randomized study of thoracolumbar burst fractures (AO Type A3—burst only) in which they compared short-segment fixation to bracing. Thirty-two patients were followed for 4 years (92% follow-up), finding superior functional outcome and pain scores in the surgical group (Roland Morris Disability Questionnaire, visual analog scale [VAS] and VAS spine scores).

Adverse Events in Operative and Nonoperative Burst Fractures

The primary aim of the present study was to compare adverse events for nonoperative and operative management of traumatic fractures of the thoracolumbar spine as previously reported in the literature. A common misperception is that operative intervention lowers the rate of complications due to early ambulation. In our review of the literature, we found 300 complications in the operative group (32.6%) versus 21 in the nonoperative group (4.8%).

Wood and colleagues⁴⁹ found a higher incidence of complications in the surgical group, despite having no major long-term advantages. A Cochrane review by Abudou et al.¹ found 2 studies that were eligible for inclu-

TABLE 1: Results of MEDLINE search—operative and nonoperative manuscripts*

Authors & Year	Journal	Study Design	CEBM Grade	No. of Pts
operative group				
Pakzad et al., 2011	<i>Can J Surg</i>	prosp	II	83
Campbell et al., 2011	<i>Neurosurg Focus</i>	prosp	II	202
Gnanenthiran et al., 2012	<i>Clin Orthop Relat Res</i>	meta	I	41
Kerwin et al., 2007	<i>J Trauma</i>	prosp	II	361
Pfeifer et al., 2012	<i>J Trauma Manag Outcomes</i>	prosp	II	70
Schnee & Ansell, 1997	<i>J Neurosurg</i>	retro	III	25
Wang et al., 2006	<i>Spine</i>	prosp	II	58
Stadhouder et al., 2008	<i>Spine</i>	retro	IV	114
Haiyun et al., 2010	<i>Spine</i>	prosp	II	37
Wei et al., 2010	<i>Spine</i>	prosp	II	85
Resnick & Benzel, 1998	<i>Neurosurgery</i>	retro	III	33
Nguyen et al., 2003	<i>J Spinal Disord Tech</i>	retro	III	10
Rechtine et al., 1999	<i>J Spinal Disord</i>	prosp	II	117
nonoperative group				
Gnanenthiran et al., 2012	<i>Clin Orthop Relat Res</i>	meta	I	38
Chapman et al., 2008	<i>Spine</i>	post hoc	IV	151
Stadhouder et al., 2008	<i>Spine</i>	parallel cohort	II	95
Wood et al., 2003	<i>J Bone Joint Surg Am</i>	RCT	I	47
Rechtine et al., 1999	<i>J Spinal Disord</i>	prosp	II	118

* CEBM = Center for Evidence-Based Medicine; meta = meta-analysis; prosp = prospective; Pts = patients; RCT = randomized controlled trial; retro = retrospective.

sion and concluded that there was insufficient evidence in this comparison of operative to nonoperative treatment of burst fractures. Furthermore, complications could not be tracked because the included studies did not track them. Siebenga and colleagues⁴² found a similar complication rate in a multicenter prospective trial randomizing AO Type A3 thoracolumbar fractures to either operative or nonoperative treatment (29% vs 20%, or 5 vs 3 complications, respectively). These findings are difficult to interpret in the face of a limited recruitment, with only 34 patients included in the study.

Rechtine and colleagues³⁶ reviewed 235 patients with

TABLE 2: Baseline characteristics in 1355 patients with thoracolumbar spine fractures

Characteristic	Group		p Value
	Op	Nonop	
total no.	919	436	0.974
no. (%) female	316 (35)	173 (40)	0.404
mean age in yrs (SD)	43.17 (11.1)	34.68 (5.5)	0.3865
Frankel grade*			
A	38	29	NA
B–D	109	63	NA
E	342	319	NA
mean LOS in days (SD)	14.2 (5.0)	20.75 (17.1)	0.3754

* From studies reporting functional status. NA = not available.

thoracolumbar trauma retrospectively, finding no difference in decubitus ulcers, thromboembolism, or mortality. There are many confounders in the population of patients with multiple traumas that are not taken into consideration in the studies we reviewed, which may confer a higher adverse event rate. For example, prior work has shown that mobilization off of a backboard, rather than surgical intervention, may be the most influential factor in preventing decubitus ulcers,¹⁴ supporting the conclusions of Rechtine et al. In a review of the nonsurgical management of thoracolumbar burst fractures, Shen and Shen⁴¹ found no cases of decubitus ulcers or thromboembolism

TABLE 3: Operative versus nonoperative complications in 1355 patients with thoracolumbar spine fractures*

Complication	Group		p Value
	Op	Nonop	
pulmonary	60	3	0.727
thromboembolic	20	9	0.841
infection (PNA, UTI, wound)	51	0	0.000875
cardiac	8	0	1
gastrointestinal	5	0	0.948
revision for instr failure	40	0	0.00396
other	116	9	
total no. (%)	300 (32.6)	21 (4.8)	0.1065

* Instr = instrumentation; PNA = pneumonia; UTI = urinary tract infection.

Review of adverse events in managing thoracolumbar fractures

in patients without neurological deficit. This is surprising in that advocates of surgery argue that surgery lowers complications related to being immobile. However, neurological grade probably plays an even greater role in adverse events, and that warrants further study.

The incidence of surgical site infection in spine surgery at major institutions is approximately 5%, ranging from 0.7% to 11.9%.⁷ The use of vancomycin in the surgical bed has been shown to lower the infection rate in several studies;^{24,31,34,43,44} however, those data were not available in any of the reviewed literature. Across the studies reviewed, the obvious difference is the incidence of thoracolumbar wound infections, which was statistically higher for the operative than for the nonoperative group, because the latter did not undergo surgery. The number of nonsurgical infections in the operative group was also higher compared with the nonoperatively treated group. Due to the varied range in complication reporting, the infections were reported in aggregate, rather than individually (pulmonary, urinary, sepsis).

Limitations of the Study

Given the lack of homogeneity among studies, this review suffers from several limitations. The major limitation of the abundant retrospective studies included in this review is the lack of a uniform patient population. In the operative group nearly two-thirds of the complications are specifically described (Table 3). This point is illustrated by Rechtine and colleagues' retrospective study,³⁶ in which the patient population had a mix of neurologically intact and incomplete patients, guided by surgeon selection. The selection bias makes interpretation of these data difficult without clearly defined inclusion criteria. It is unknown how many patients were deemed not to be medical candidates and therefore biased the nonsurgical complications. However, the crude complication rate was particularly low in the nonsurgical group (4.8%).

Due to the lack of agreement on the acceptable approach to the thoracolumbar junction, whether anterior, posterior, or combined, the complications were not stratified across studies in the operative category. Regardless of approach, it is evident that there were more complications in the surgical group, contributing to the 32.6% crude complication rate. More than one-third of the complications in the operative group were procedure related; namely wound infections and implant failures. Determining approach-related complications in this study was not feasible because of the lack of recorded complications and low patient population.

There was a lack of agreement among studies on the definition of a complication as well as the postoperative time period during which a complication can be considered treatment related. The reported studies were predominantly retrospective, and that type of study has been shown to find lower complication rates than prospective studies,^{9–11} as well as less consistent follow-up.

Variability of the LOS data in both groups illustrates that straightforward comparisons between the groups regarding "nonprocedural" complications is difficult. This variability is probably due to the distribution of the multiple traumas seen.

Conclusions

Due to the limited number of high-quality studies, conclusions related to complication rates of operative and nonoperative management of thoracolumbar traumatic injuries cannot be definitively made. Further prospective, randomized studies of operative versus nonoperative management of thoracolumbar and lumbar spine trauma, with standardized definitions of complications and matched patient cohorts, will aid in properly defining the risk-benefit ratio of surgery for thoracolumbar spine fractures.

Disclosure

Dr. Vaccaro is a board member for AOSpine, Innovative Surgical Design, Association of Collaborative Spine Research, and Spinicity. He is a consultant for Stout Medical, Gerson Lehrman Group, Guidepoint Global, Medacorp, Innovative Surgical Design, and Orthobullets. He has received clinical or research support for the study described (includes equipment or material) from Stryker Spine, NuVasive, and Cerapedics. He receives royalties from DePuy, Medtronic, Stryker Spine, Biomet Spine, Globus, Aesculap, and NuVasive. He has direct stock ownership in the following companies: Replication Medica, Globus, K-2 Medical, Paradigm Spine, Stout Medical, Spine Medica, Computational Biodynamics, Progressive Spinal Technologies, Spinology, Small Bone Innovations, Cross Current, Syndicom, In Vivo, Flagship Surgical, Advanced Spinal Intellectual Properties, Cytonics, Bonovo Orthopaedics, Electrocore, Gamma Spine, Location Based Intelligence, FlowPharma, R.S.I., Rothman Institute and Related Properties, Innovative Surgical Design, and Spinicity. Dr. Harrop is a consultant for DePuy Spine, and he serves on advisory boards for Bioventus and Tejin. Dr. Arnold is a consultant for Medtronic Sofamor Danek, Lifespine, Integra Life, SpineWave, Stryker Spine, MIEMS, and AOSpine North America. He has received an honorarium from the University of Missouri, and he owns stock in Z-plasty.

Author contributions to the study and manuscript preparation include the following. Conception and design: Harrop, Ghobrial, Vaccaro. Acquisition of data: Ghobrial, Maulucci, Dalyai. Analysis and interpretation of data: Harrop, Ghobrial, Maulucci, Dalyai, Fehlings. Drafting the article: Harrop, Ghobrial, Maulucci, Dalyai. Critically revising the article: Harrop, Vaccaro. Reviewed submitted version of manuscript: Harrop, Ghobrial, Street, Arnold. Statistical analysis: Maltenfort. Study supervision: Harrop.

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Review of adverse events in managing thoracolumbar fractures

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