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Radiographic Outcomes Following Various Treatment Options of Thoracolumbar Burst Fractures

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ABSTRACT

Background: Thoracolumbar burst fractures include a spectrum of treatment options ranging from conservative management to multilevel fusion with or without corpectomy. Given the variability of treatment options, consideration of radiographic outcomes with different treatment modalities should be a critical consideration in management.

Methods: A retrospective review was conducted evaluating all patients presenting with spine fractures over a 7-year period. Inclusion criteria were limited to adults with acute, traumatic burst fractures of the thoracolumbar joint levels T11-L2. Patients were categorized by nonoperative management, short-segment fusion, multilevel fusion without anterior column reconstruction, and corpectomy. Radiographic information collected included kyphotic angle (KA), Cobb angle (CA), and Gardner angle (GA).

Results: In total, 117 patients (70.5%) were successfully treated nonoperatively, 4 (2.4%) underwent short-segment fusion, 28 (16.9%) underwent multilevel fusion, and 12 (7.2%) underwent corpectomy. All nonoperative patients demonstrated significantly worse kyphosis at 1-year follow-up as measured by KA, CA, and GA ($P < 0.001$). Patients undergoing corpectomy had the largest improvement in kyphosis with an average improvement of 14.1° on KA, 8.1° on CA, and 11.0° on GA ($P < 0.001$, $P = 0.098$, and $P = 0.004$, respectively). In comparison, patients undergoing multilevel fusion showed an average improvement of 2.6°, 2.7°, and 3.3° of correction on GA, CA, and KA, respectively ($P > 0.05$).

Conclusions: Nonoperative and short-segment fusion burst fracture patients demonstrated significantly worse kyphosis at 1-year follow-up. Patients undergoing corpectomy demonstrated a superior improvement in kyphotic correction compared with those undergoing multilevel fusion and short-segment fusion.

Level of Evidence: 3.

Lumbar Spine

Keywords: burst fracture, spine, trauma

INTRODUCTION

Burst fractures account for 10% to 20% of all spinal fractures.^{1,2} Approximately two-thirds of these fractures occur at the thoracolumbar junction.³ This segment is particularly vulnerable to axial trauma because of its unique biomechanical stressors caused by the juxtaposing static, kyphotic thoracic spine and the dynamic, lordotic lumbar spine. Management of these fractures ranges from conservative management with or without an orthotic brace to one of several different surgical approaches. Some of these approaches include short-segment fusion (SF), multilevel fusions (MFs), and corpectomy. Indications for surgical intervention in burst fractures remain controversial, as are the indications for specific surgical approaches in this population, in the absence of neurologic deficit.⁴ This study aims to evaluate the relative level of kyphotic

change following the major treatment options in use for this patient population.

METHODS

A retrospective review was conducted evaluating all patients presenting with spine fractures from the years 2010 to 2017. Inclusion criteria were limited to adults with acute, traumatic burst fractures of the thoracolumbar joint levels T11-L2. Acute was defined as an injury occurring within 3 weeks of presentation. Burst fractures were identified when the fracture involved the anterior and middle columns with retropulsion of posterior wall bone fragments into the spinal canal. Exclusion criteria covered patients who did not present for follow-up, patients with chronic burst fractures, patients with nontraumatic vertebral body collapse (eg, tumor and tuberculosis), patients who presented with severe

traumatic brain injury, and patients with serious injuries associated with other major organs. Total spine computed tomographic images were obtained on all patients at presentation to the emergency department. Upright anteroposterior and lateral plain radiographs were obtained for all patients before discharge from their initial hospital stay and at each follow-up appointment. Final follow-up was defined as radiographs obtained from 6 months to 2 years postoperatively. Patients were categorized into nonoperative management with the use of orthosis, operative SF, operative MF, and operative corpectomy. A subset of the nonoperative patients presented after their initial hospital discharge for delayed surgical (DS) intervention and was categorized as a separate group. Data collected from charts included demographic information, comorbidities, level of injury, presence of neurologic deficit at presentation, and imaging characteristics measured from initial and follow-up imaging. Demographic and comorbidity information recorded included age, sex, body mass index, smoking status, posthospitalization placement location (home vs inpatient rehabilitation), presence of osteopenia or osteoporosis, and presence of corticosteroid use. Imaging characteristics were obtained including: kyphotic angle (KA), Gardner angle (GA), and Cobb angle (CA).

Categorical variables were assessed using a χ^2 or an analysis of variance test. Continuous variables were assessed utilizing a student's 2-tailed *t* test. The change in radiographic measures over time was studied using individual radiographic review at 1-year follow-up across all groups. For all analyses, a significance level of 0.05 was employed. Statistics were analyzed using Microsoft Excel version 2108.

RESULTS

In total, 166 patients met inclusion and exclusion criteria and were included in analysis. Overall mean patient age was 53 (range, 18–96) years. Of those patients, 117 patients (70.5%) were treated successfully with medical management, 4 (2.4%) underwent SF, 28 (16.9%) underwent MF, and 12 (7.2%) underwent corpectomy. Of those who underwent surgical intervention, 5 (3.0%) were treated with DS intervention (Table 1). Conservative management was successful in 117 (95.9%) of the 122 patients who initially received nonoperative management. Indications for surgical intervention in the DS group included persistent localized pain in 3 patients, progressive kyphosis in 1 patient, and development of

Table 1. Breakdown of patient population by treatment group.

Treatment Group	Number of Patients (% of Total)
Nonoperative treatment	
Total	122
Successful	117 (70.5%)
Failed	5 (3.0%)
Operative treatment	
Total	44
Single-level fusion	4 (2.4%)
Multilevel fusion	28 (16.9%)
Corpectomy	12 (7.2%)

new neurologic deficit in 1 patient. The average period of time between hospital discharge and surgical intervention in the DS group was 6.8 (range, 1–12) months.

Analysis of variance demonstrated a significant difference in mean age between the treatment groups ($P = 0.01$, Table 2), with older average age in the nonoperative group. No other significant demographic difference was identified in body mass index, vertebrae level, smoking status, discharge placement, incidence of osteopenia or osteoporosis, or cortical steroid use between treatment groups ($P > 0.05$). Patients presenting with neurologic deficit were more likely to have MF or corpectomy operations than any other form of management ($P = 0.001$, Table 2).

Pretreatment and 1-year post-treatment, KA, CA, and GA were compared. All patients in the medical management group demonstrated a statistically significant worse kyphosis as measured by KA, GA, and CA ($P < 0.001$, Tables 3–5) at final follow-up. The failure rate of medical management was 5 of 122 patients (4.1%) ultimately required surgery. Patients undergoing corpectomy had the largest improvement in kyphosis with an average improvement of 14.1° on KA, 7.6° on CA, and 11.0° on GA ($P < 0.001$, $P = 0.098$, and $P = 0.004$, respectively). SF demonstrated worsening kyphosis similar to nonsurgical treatment; however, this was not statistically significant. In comparison with corpectomy, MF demonstrated reduced kyphosis of 3.3° on KA, 2.7° on CA, and 2.6° on GA; however, this similarly did not reach significance ($P > 0.05$, Tables 3–5).

DISCUSSION

The management of thoracolumbar burst fractures is controversial, with many authors recommending surgical or nonsurgical intervention. While several scores exist to help guide clinical decision-making, such as the thoracolumbar injury classification and severity score, little to no guidance regarding the optimal surgical approach exists in cases that do require surgical intervention.⁵ Given this lack of guidance, practitioners should be well versed in the benefits and limitations of

Table 2. Patient characteristics by treatment group.

Variable	Nonoperative (n = 117)	Single Fusion (n = 4)	Multilevel Fusion (n = 28)	Corpectomy (n = 12)	Delayed Surgery (n = 5)	P Value
Age, y, mean (SD)	57.2 (20)	47 (10.4)	44 (18.4)	46.5 (15.6)	48.6 (6.9)	0.010
Sex						
Men	57 (48.7%)	2 (50%)	19 (67.9%)	8 (66.7%)	1 (20%)	0.170
Women	60 (51.3%)	2 (50%)	9 (32.1%)	4 (33.3%)	4 (80%)	
Body mass index, mean (SD)	26.6 (6.9)	28.5 (3.1)	27.5 (4.9)	26.4 (3.6)	27 (6.1)	0.947
Level						
T11	6 (5.1%)	0 (0%)	3 (10.7%)	0 (0%)	1 (20%)	0.150
T12	24 (20.5%)	2 (50%)	8 (28.6%)	3 (25%)	3 (60%)	
L1	66 (56.4%)	0 (0%)	10 (35.7%)	6 (50%)	1 (20%)	
L2	21 (17.9%)	2 (50%)	7 (25%)	3 (25%)	0 (0%)	
Smoker						
Never	75 (64.1%)	3 (75%)	17 (60.7%)	7 (58.3%)	4 (80%)	0.978
Former	14 (12%)	0 (0%)	2 (7.1%)	2 (16.7%)	0 (0%)	
Current	28 (23.9%)	1 (25%)	9 (32.1%)	3 (25%)	1 (20%)	
Placement						
Home	73 (62.4%)	3 (75%)	20 (71.4%)	9 (75%)	3 (60%)	0.834
Rehabilitation	44 (37.6%)	1 (25%)	8 (28.6%)	3 (25%)	2 (40%)	
Neurologic deficit						
Intact	117 (100%)	4 (100%)	26 (92.9%)	9 (75%)	5 (100%)	0.001
Deficit	0 (0%)	0 (0%)	2 (7.1%)	3 (25%)	0 (0%)	
Osteopenia/osteoporosis						
None	73 (62.4%)	4 (100%)	22 (78.6%)	9 (75%)	5 (100%)	0.729
Osteopenia	19 (16.2%)	0 (0%)	2 (7.1%)	1 (8.3%)	0 (0%)	
Osteoporosis	25 (21.4%)	0 (0%)	4 (14.3%)	2 (16.7%)	0 (0%)	
Corticosteroid use						
No	108 (92.3%)	4 (100%)	26 (92.9%)	12 (100%)	5 (100%)	>0.99
Yes	9 (7.7%)	0 (0%)	2 (7.1%)	0 (0%)	0 (0%)	

Note: Data presented as n (%) unless otherwise indicated. Analysis of variance test conducted on all patient treatment groups with a significance threshold of $P = 0.05$ demonstrating when there is a significant difference in the mean between the groups.

Table 3. Kyphotic angle change over time.

Patient No.	Treatment Type	Initial (°)	1 y (°)	P Value	Change (°)
4	Short segment	15.8 ± 10.9	18.2 ± 6.9	0.73	-2.4
28	Multilevel	14.9 ± 8.3	11.6 ± 7.9	0.13	3.3
12	Corpectomy	18.5 ± 7.4	4.4 ± 8.5	<0.001	14.1
5	Delayed	12.8 ± 7.6	21.2 ± 11.1	0.21	-8.4
117	Nonsurgical	11.6 ± 7.2	17.7 ± 7.3	<0.001	-6.1

a variety of treatment approaches. In the present article, we review the radiographic outcomes of a variety of treatment options to provider practitioners with realistic radiographic outcomes following these treatments.

In the setting of burst fractures, kyphosis is of particular interest because progressive kyphosis may result in worsening pain and associated deformity. While this may make sense intuitively, the correlation between functional outcomes and radiographic kyphosis has been unclearly defined in the literature. Historically, radiographic kyphosis has not been associated with long-term functional outcomes. In a study by Cantor et al in 1993, 18 neurologically intact patients were treated with bracing and early ambulation. At final

follow-up, patients were said to have a good functional recovery with no delayed neurologic function, demonstrating bed rest was not required.⁶ In another retrospective review by Weinstein et al, also in 1993, 41 patients who presented with thoracolumbar burst fractures were evaluated. At 2-year follow-up, 49% had an excellent outcome compared with 22% who had a fair outcome and 12% who had a poor outcome.⁷ In our study, medical management predictably demonstrated the worst kyphotic trend over time as measured on KA, CA, and GA. However, the failure rate remained low as only 5 of 122 patients (4.1%) ultimately required surgery. This rate supports studies finding that while kyphosis is known to progress in patients treated with

Table 4. Cobb angle change over time.

Patient No.	Treatment Type	Initial (°)	1 y (°)	P Value	Change (°)
4	Short segment	-11.9 ± 9.1	-18.0 ± 12.2	0.46	-6.1
28	Multilevel	-15.5 ± 9.5	-12.8 ± 8.6	0.28	2.7
12	Corpectomy	-15.1 ± 8.77	-8.3 ± 10.4	0.098	7.6
5	Delayed	-14.3 ± 4.9	-22.4 ± 13.7	0.27	-8.1
117	Nonsurgical	-11.1 ± 7.4	-17.4 ± 9.2	<0.001	-6.4

Table 5. Gardner angle change over time.

Patient No.	Treatment Type	Initial (°)	1 y (°)	P Value	Change (°)
4	Short segment	17.3 ± 4.7	24.1 ± 5.1	0.099	-6.8
28	Multilevel	16.8 ± 9.4	14.2 ± 8.3	0.28	2.6
12	Corpectomy	22.3 ± 7.0	11.3 ± 9.5	0.004	11.0
5	Delayed	14.8 ± 7.5	23.3 ± 13.2	0.26	-8.5
117	Nonsurgical	13.9 ± 7.9	21.9 ± 8.3	<0.001	-8.1

medical management, progressive kyphosis is not necessarily associated with worsening symptoms or the need for surgery.⁸⁻¹⁰ Additionally, our results suggest the average amount of worsened kyphosis demonstrated in this study at 1 year (6.1° on KA, 6.4° on CA, and 8.1° on GA) is not associated with failure of medical management despite that the average absolute values of these angles at 1 year remained high (>17°–21°) in all 3 metrics: KA, CA, and GA (Tables 3–5).

While some studies demonstrated no clear correlation with outcomes and KA in patients undergoing nonsurgical management, one of the principle biomechanical goals of all spine surgery is the restoration of normal upright spinal alignment. While KA should not be considered a surgical indication in the setting of acute burst fracture, careful consideration of surgical options should include consideration of regional anatomy to minimize long-term progressive deformity, worsening adjacent segment disease, and worse functional outcomes secondary to poor sagittal balance.¹¹ Among the surgical interventions evaluated in this study, our results showed that corpectomy demonstrated a significantly improved CA kyphosis of 7.6° on average compared with 2.7° on posterior MF. This improvement was consistently evident in all 3 radiographic metrics. In addition to improved kyphosis, anterior column reconstruction with corpectomy typically does not require long-segment posterior fusion, resulting in more levels of preserved spinal motion.

The use of short-segment posterior fixation in the setting of burst fractures is controversial because it provides little biomechanical resistance against axial compressive forces. Biomechanically, these constructs represent a cantilever beam construct rather than a 3-point bending construct, which is inferior at providing anterior column support. When considering short-segment posterior fusion vs MF or anterior column reconstruction, the McCormack and Gains load-sharing score is frequently considered.¹² This scoring system was initially published in 1993 with data supporting its ability to predict short-segment posterior instrumentation and fusion failure.¹² In addition to the McCormack and Gains score, consideration of the AO Spine classification may also be utilized as it differentiates complete

vs incomplete burst fractures in type A3 and A4 fractures, thus providing some insight into the integrity of the anterior column. In our series, the use of SF was associated with poor radiographic outcomes with an average change in CA of -6.1°. Of note, some authors have demonstrated excellent radiographic outcomes with the use of intermediate screws for short-segment fixation; however, this technique was not utilized in our patient population.¹³

While our study provides much information regarding radiographic outcomes of thoracolumbar burst fractures, many limitations are present. Future studies should evaluate radiographic parameters compared with patient-reported outcome measures to ensure these measures provide meaningful benefit to patient's quality of life. Additionally, our study only evaluated burst fractures as a whole, lending much heterogeneity in the structural integrity of the anterior column. For this reason, future studies should consider including the AO Spine classification system and the McCormack and Gains load sharing score as predictors of kyphosis.

CONCLUSION

In conclusion, medical management of acute burst fractures without neurologic deficit led to a statistically significant progression of kyphosis as measured by KA, CA, and GA at 1 year, with failure rates of 4.1%. Among patients treated operatively, those treated with corpectomy demonstrated a significantly improved degree of kyphosis at 1 year, while those treated with SF and MF demonstrated minimal change in kyphosis.

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