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Nonoperative Management in Neurologically Intact Thoracolumbar Burst Fractures: Clinical and Radiographic Outcomes

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Study Design. Retrospective cohort study.

Objective. The identification of factors that lead to the failure of nonoperative management in neurologically intact thoracolumbar burst fractures.

Summary of Background Data. The treatment of thoracolumbar burst fractures (TLBF) can be controversial, particularly in the neurologically intact. Surgery for intact burst fractures has been advocated for early mobilization and a shorter hospital stay. These goals, however, have not always been achieved, rejuvenating an interest in nonoperative treatment.

Methods. Sixty-eight neurologically intact patients with burst fractures of the thoracolumbar junction (T11-L2), and a thoracolumbar injury classification and severity score (TLICS) of 2, were treated at our institution. Based on CT scans, patients were scored based on the load-sharing classification (LSC) scale. Initial treatment consisted of bracing in clamshell thoracolumbar orthosis and gradual mobilization.

Results. Owing to pain limiting mobilization, 18 patients failed nonoperative management and required instrumentation. Those who failed nonsurgical management were significantly more kyphotic ($8^\circ \pm 10$) and stenotic ($52\% \pm 14\%$) than those successfully treated nonoperatively ($3^\circ \pm 7$ and $63 \pm 12\%$, respectively). The LSC score of those undergoing surgery (6.9 ± 1.1) was also greater than those successfully treated nonoperatively (5.8 ± 1.3, $P = 0.006$). Length of hospitalization was longer, and hospital charges higher in those requiring surgery compared to the nonoperative group. At follow-up there was no difference between groups in the visual analog score for pain (VAS) or the Oswestry disability index.

Conclusion. Owing to pain limiting mobilization, a quarter of neurologically intact patients with thoracolumbar burst fractures and a TLICS score of 2 failed nonsurgical management. The greater the kyphosis, stenosis, and fragmentation of the fracture, the more likely patients required surgery. In addition to the TLICS classification, other radiographic and clinical parameters should be included in selecting appropriate treatment strategy. The cost savings with nonoperative treatment of intact burst fractures, when appropriate, are significant.

Key words: burst fracture, recumbency, spinal fracture, spinal instrumentation, spinal trauma.

Level of Evidence: 3

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Surgery for thoracolumbar burst fractures (TLBF) is advocated for neural decompression and stabilization. The argument for such management in neurologically intact patients has been early mobilization and a shorter hospital stay. These goals, however, have not always been achieved, rejuvenating an interest in nonoperative recumbent treatment. Such nonoperative management of TLBF is by no means novel, and was initially advocated in the 1940s by Ludwig Guttman[1] at the Stoke Mandeville Hospital, and later by Nicoll[2] at the Mansfield General Hospital. This tradition was later continued by Frankel[3] and Bedbrook.[4] In recent years, nonoperative treatment of neurologically intact TLBF has been adopted and found to be associated with excellent results.[5–11] Other studies found surgical management of these fractures to be equally rewarding, without significant advantage of one surgical approach over another.[12–16]

There is little disagreement that surgical treatment for burst fractures in the setting of neurological deficit is the appropriate route of management. The more difficult

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question is how to handle such fractures in the absence of deficit. Studies have addressed this question in a prospective randomized manner. However, in general, such studies have been few and far between.[10,14] Whereas one has shown surgical treatment to have an advantage,[14] the other showed no substantial benefit of surgery over conservative treatment. In an attempt to shed more light on this contentious issue, the following retrospective study was conducted. All patients with thoracolumbar burst fractures since 2005 have been followed prospectively, and their demographic, clinical, and radiographic data compiled and analyzed retrospectively.

MATERIALS AND METHODS

Since 2005, 255 patients with thoracolumbar burst fractures were treated by our department. There were 172 patients with neurological deficit, all of whom were treated with decompression and instrumentation. The remaining 83 were neurologically intact and were given a trial of nonoperative treatment with gradual mobilization with sequential lateral radiographs at 45° and 90° to watch for instability. Bracing in thoracolumbar clamshell orthosis was applied for comfort and protection, and generally maintained for 8 to 12 weeks. The current cohort under study consists of 68 patients with fractures between T11 and L2 and an intact posterior ligamentous complex (PLC) as deemed by our neuroradiologist. Demographic, clinical, and radiographic data were accrued prospectively, and herein analyzed retrospectively (Institutional Review Board approval #201306760: Outcomes of burst fractures: an investigation of outcomes of subjects having surgery *vs.* no surgery). There were 34 men and 34 women, ages 49 ± 19 and BMI of $29 \pm 6\,kg/m^2$. Causes of injury were falls in 39, car accidents in 20, motorcycle accidents in 3, equestrian in 2, and 1 each from lifting, snowmobile, mower, and farm related. There were 2 fractures at T11, 22 at T12, 24 at L1, and 20 at L2. These fractures involved the anterior and middle columns as described by Denis[17] and were classified using the Thoracolumbar Injury Classification and Severity (TLICS) score.[18,19] The TLICS score utilizes the presence or absence of neurological deficit, the integrity of the PLC, and the morphology of the fracture. The cohort herein reported had a TLICS score of 2 (neurologically intact = 0, 2 column burst fractures = 2, and PLC intact = 0, for a total of 2). Fractures with deficit, fracture dislocations, flexion distraction injuries, extension fractures as seen in ankylosing spondylitis or DISH, and flexion compression fractures without retropulsion were excluded from this review. Patients on admission underwent supine plain radiographs, CT, and MRI. Segmental kyphosis was measured on lateral plane radiographs using the angle subtended between the adjacent intact endplates. Residual anteroposterior canal diameter at the injury site was measured from CT scans and expressed as a percentage of the intact diameter averaged between the rostral and caudal intact canal. MRI-, T1-, and T2-weighted images, and the Short Tau Inversion Recovery (STIR) sequence were used to assess the integrity of the PLC consisting of the supra- and infraspinous ligaments, the ligamentum flavum, and the facet capsules.[20–23] Integrity of PLC was evaluated by the institution's neuroradiologist (Toshio Moritani, MD), who was not informed of management or outcome. Serial radiographs before and at 3-, 6-, and 12-month intervals were obtained on clinic visits. Using the load-sharing classification (LSC)[5,21,24,25] fractures were also scored based on the degree of comminution and apposition of the fracture fragments, and the kyphotic deformity. Scoring was performed by a neurosurgeon without knowledge of the patient's management (Kingsley Abode-Iyamah, MD). For comminution, a score of 1, 2, or 3 was given to fractures involving 1/3, 1/3 to 2/3, or more than 2/3 of the body, respectively. Bone fragment displacement of 0 to 1 mm, 2 mm, or more over 50% or less of the vertebral body, and 2 mm or more over 50% of the vertebral body or more received scores of 1, 2, and 3, respectively. The third component of the LSC is based on the amount of kyphosis correction necessary to restore normal alignment. Accordingly, kyphosis of 3° or less, 4° to 9°, and 10° or more received scores of 1, 2, or 3. Thus, according to this scale, fractures received a total grade of 3 to 9 points. At follow-up, patients were asked to complete the Oswestry disability index (ODI)[26] and score their pain on a visual analogue scale (VAS) from 0 to 10. Statistical software SPSS for Windows 20.0 was used for analysis. Independent *t*-test was used to compare the means for numerical data. Categorical data were tested using the Chi-Square test. Binary logistic regression was used to find the risk factors that can be used to predict the need for surgery. Significance was at the $P < 0.05$ level.

RESULTS

Nonoperative Management

Fifty patients were treated with the above regimen and were discharged in 6 ± 6 days. This cohort consisted of 23 men and 27 women, ages 49 ± 19 and BMI of $29 \pm 6\,kg/m^2$ (Table 1, Figure 1A, B, and C). Follow-up of this cohort was for 15 ± 15 months. Residual canal on admission measured $63\% \pm 12\%$ and angulation $3° \pm 7°$ (Figure 2). The LSC score of this cohort was 5.8 ± 1.3 (Table 1). Because of pain attributed to instability, 3 patients (6%) of this cohort failed nonoperative management, requiring surgical intervention within 5 ± 2 months from injury. Surgical treatment consisted of corpectomy and anterior instrumentation in 1 and posterior instrumentation in 2. Length of stay for surgery was 11 ± 8 days. This resulted in an overall hospital stay for the entire nonoperative cohort of 7 ± 6 days (Table 2). At follow-up, local angulation had progressed to $13° \pm 8°$. As some patients had relocated and could not be reached, the Oswestry disability and VAS were retrievable in 33 patients and were 25 ± 23 and 1.9 ± 1.9, respectively. Physician, hospital, and total charges amounted to $\$7{,}800 \pm 12{,}000$, $42{,}700 \pm 48{,}800$, and $50{,}500 \pm 60{,}700$, respectively (Table 2).

TABLE 1. Demographic and Radiographic Data

Parameter	Cohort	Mean	Standard Deviation	*P*
Age (yr)	Operative	49	18	0.81
	Nonoperative	49	19	
BMI (kg/m^2)	Operative	28	5	0.87
	Nonoperative	29	6	
Residual Canal (%)	Operative	52	14	0.003
	Nonoperative	63	12	
Angulation Admission	Operative	8	10	0.017
	Nonoperative	3	7	
Angulation Follow-up	Operative	1	10	<0.0001
	Nonoperative	13	8	
Load-Sharing Classification	Operative	6.9	1.1	0.006
	Nonoperative	5.8	1.3	

BMI indicates body mass index.

Operative Treatment

Eighteen patients, 11 men and 7 women, with ages 49 ± 18 years and BMI of 28 ± 5 kg/m^2 (Table 1, Figure 3A, B, C, D), failed initial trial of nonoperative treatment due to pain limiting mobilization which prevented discharge. Consequently, this cohort of 18 underwent surgery for stabilization. On admission, the residual canal measured $52\% \pm 14\%$ and angulation $8^\circ \pm 10^\circ$ ($P = 0.003$ and $P = 0.017$ compared to the nonoperative group, respectively). The LSC score of this operative cohort (6.9 ± 1.1) was significantly greater than the nonoperative ($P = 0.006$). By the time of discharge, kyphosis had been corrected significantly to $-2^\circ \pm 8^\circ$. Surgery consisted of a corpectomy, interbody cage, and anterior in instrumentation in 11 and posterior instrumentation in 7. Two patients required additional surgery: first revision of anterior instrumentation with posterior instrumentation within 11 days of the initial surgery, and the second supplementary posterior instrumentation within 1 week after anterior corpectomy and stabilization. Thus, the revision rate in the surgical group was 2 of 18, or 11%. The overall hospitalization was 13 ± 7 days ($P = 0.001$ compared to the nonoperative group, Table 2). Follow-up of this cohort was for 21 ± 17 months, with local kyphosis progressing from $-2^\circ \pm 8^\circ$ at discharge to $1^\circ \pm 10^\circ$ ($P < 0.0001$ compared to the nonoperative cohort, Figure 2). For the operative cohort, physician, hospital, and total

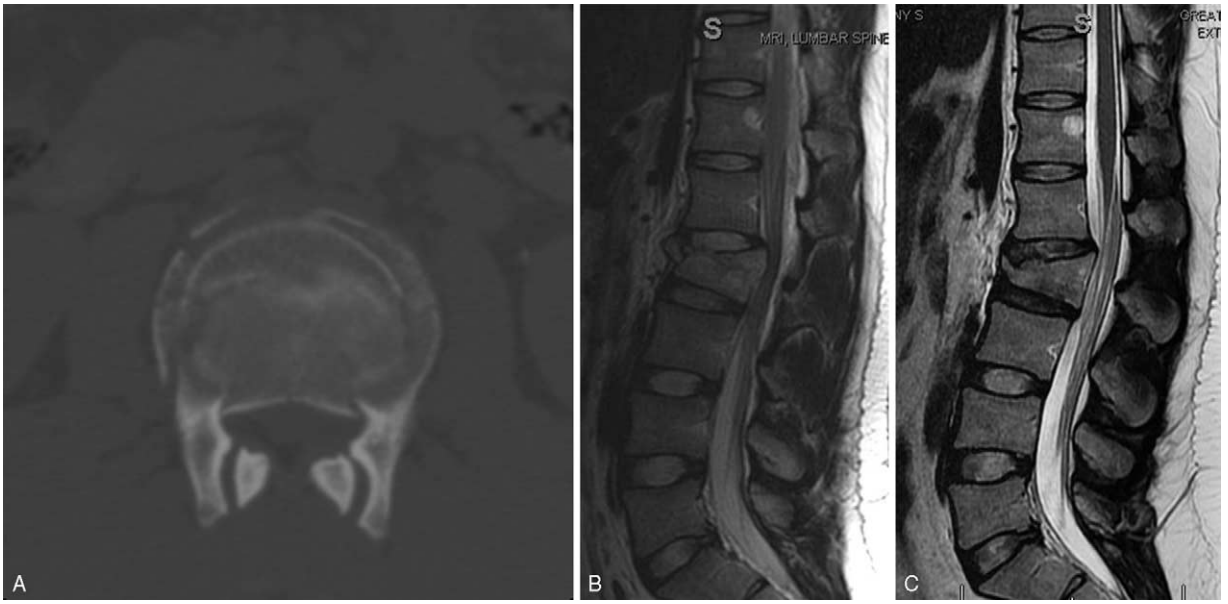

Figure 1. A 19-year-old man fell from a height of 20 feet sustaining an L1 burst fracture without neurological deficit. CT scan (**A**) reveals the retropulsion of bone and a residual canal of 75%. Sagittal T-2 weighted MRI (**B**) shows the canal compromise and minimal kyphosis at 3°. Though the posterior longitudinal ligament is stretched, the inter- and supraspinous ligaments and ligamentum flavum are preserved. The patient was treated nonoperatively and returned 8 years later with complaints of back and leg pain for 6 months. Sagittal T-2 MRI (**C**) shows remodeling of the spine without significant canal compromise, but persistence of kyphosis now measuring 11°. Patient is being treated conservatively with anti-inflammatories.

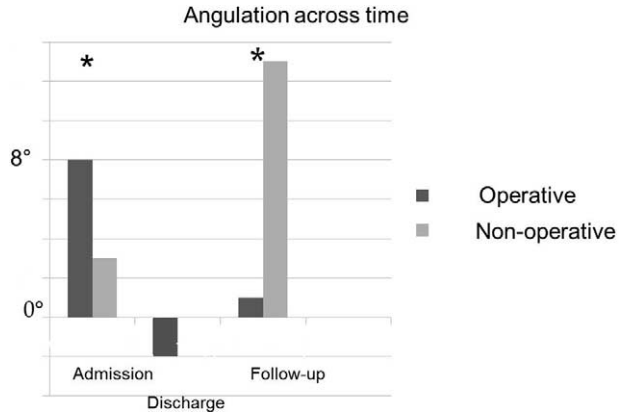

Figure 2. Progress of kyphosis across time is treatment dependent.

charges were $41,700 \pm 21,400$, $144,000 \pm 66,600$, and $185,700 \pm 86,700$, respectively, all of which were significantly greater than the nonoperative group ($P < 0.0001$, Table 2). The higher charges for the surgical cohort reflect the longer hospital stay, surgeon's fees, and cost of implants. At follow-up, the ODI and VAS were retrieved in 15 patients and were 27 ± 25, and the VAS 3.0 ± 2.8 ($P = 0.769$ and $P = 0.121$ compared to the nonoperative cohort, respectively, Table 1).

The earlier results reveal that patients who failed nonoperative treatment requiring surgery on account of their pain had significantly greater local kyphosis, stenosis, and LSC score compared to those not undergoing initial surgery.

DISCUSSION

The therapeutic options for burst fractures include conservative or surgical management. For patients who are neurologically intact, nonoperative treatment may prove sufficient.[6–8,10,11,14,27–29] Surgery is undertaken when neurological deficits and/or persistent pain are present, or the fracture is deemed unstable with disruption of the posterior ligaments. In the absence of neurological deficit or biomechanical instability, the decision favoring one approach (surgical or nonsurgical) becomes more contentious and ambiguous. In the study by Wood *et al*,[10] 47 intact patients with intact TLBFs were randomized to operative (24) or nonoperative (23) treatment. Length of hospitalization was 11 and 8 days for the operative and nonoperative cohorts, respectively, with mean follow-up of 44 months. There did not appear to be a particular advantage of one approach over another in terms of maintenance of local kyphotic angulation at follow-up. Complications were far more frequent in the surgical group (16/24) compared to the nonoperative group (3/23). No significant difference was found between the 2 groups with respect to return to work or pain scores. Final scores on the SF-36 and Oswestry questionnaires were similar between groups, although favored nonoperative treatment. A similar randomized trial was conducted by Siebenga *et al*[14] involving 16 patients treated nonoperatively and 18 operatively. Mean length of follow-up was 4.3 ± 16.5 years, with a range of 2.0–6.6 years. Hospital stays for the surgical and nonsurgical cohorts were 15 and 12 days, respectively. Local angulation progressed in the nonoperative group from 13° on admission to 19° at 4 years of follow-up, from 11° on admission to 2° at discharge, and 8° at follow-up in the surgical group. Complications were 29% and 20%, respectively. All functional outcome scores (VAS Pain, VAS Spine Score, and RMDQ-24) showed significantly better results in the operative group. The percentage of patients returning to their original jobs was found to be significantly higher in the operative group.

Similar favorable results with nonoperative management of thoracolumbar burst fractures have been further replicated with other studies.[6,8,11,27,28] In the retrospective review by Tropiano *et al*,[9] 41 intact patients with TLBFs were treated with casting and followed for a mean of 34 months and a minimum of 24 months. Sixty-four percent of patients had minimal or no pain. Eight percent had constant severe pain. At time of injury, 71% of patients were employed. However, at 8-month follow-up, only 58% were

TABLE 2. Hospital stay, charges, and outcomes

Parameter	Cohort	Mean	Standard Deviation	*P*
Hospital Stay	Operative	13	7	0.001
	Nonoperative	7	6	
Physician Charges ($)	Operative	41700	21400	<0.0001
	Nonoperative	7800	12000	
Hospital Charges ($)	Operative	144000	66600	<0.0001
	Nonoperative	42700	48800	
Total Charges ($)	Operative	185700	86700	<0.0001
	Nonoperative	50500	60700	
Oswestry	Operative	27	25	0.769
	Nonoperative	25	23	
VAS	Operative	3	2.8	0.121
	Nonoperative	1.9	1.9	

VAS indicates visual analog scale.

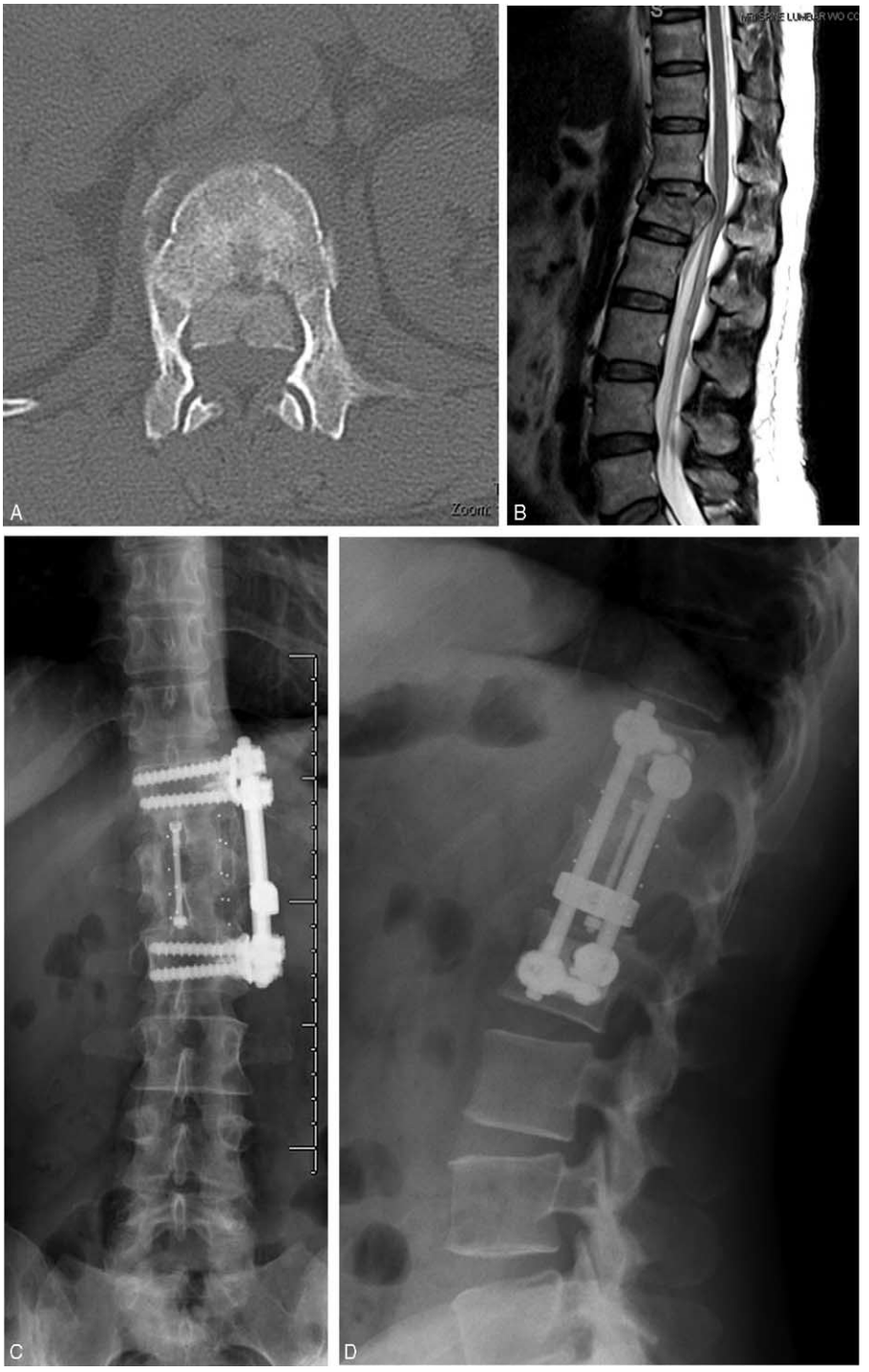

Figure 3. A 53-year-old woman fell from her deck a height of 8 ft sustaining an L1 burst fracture without neurological deficit. Axial CT (**A**) shows retropulsion of bone into the canal. Sagittal T2 MRI (**B**) shows intact posterior ligamentous complex. She was hospitalized for 5 days and was discharged home in a thoracolumbar orthosis. Owing to intractable pain, she was readmitted 18 days after her injury, and underwent L1 corpectomy, grafting with carbon fiber reinforced polymer cage, and anterior instrumentation. Anteroposterior (**C**) and lateral (**D**) radiographs obtained 18 months later show bony fusion and maintained corrected alignment.

employed. Closed reduction resulted in significant correction of regional kyphosis from a mean of 3.4° to −7.6° after reduction. However, this progressed to 4.6° at latest follow-up. There were no cases of neurological deterioration in this series. Three cases ultimately required surgery for back pain from instability and ligamentous disruption. The consensus from the aforementioned studies and other meta-analyses is the inconsistency of outcomes, rendering a decision in favor of operative *versus* nonoperative treatment inconclusive.[8,29-32]

In our management of neurologically intact burst fractures, with intact PLC or a TLICS score of 2, patients were initially all treated nonoperatively with bracing and gradual mobilization. Thoracolumbar braces were used in all patients, although recent reports have shown that braces did not add sufficiently to clinical outcomes to justify their cost or use.[33] Since this report, we have moved away from the routine use of bracing in these types of fractures. This nonsurgical approach was successful initially in 50 of our patients, although 3 (6%) ultimately required surgery 5 ± 2

months from injury. The remaining 18 (26.5%) failed initial conservative management, requiring surgery due to incapacitating pain that prevented mobilization and early discharge. In the group requiring surgery, local kyphosis ($8^\circ \pm 10$), stenosis ($52 \pm 14\%$), and LSC (6.9 ± 1.1) on admission were worse than in the nonoperative group ($3^\circ \pm 7$, 63 ± 12, and 5.8 ± 1.3, $P = 0.017$, $P = 0.003$, and $P = 0.006$, respectively, Table 1, Figure 2). This reflects the greater degree of vertebral body fragmentation and loss in height in symptomatic patients requiring surgery. On follow-up, local kyphosis had been corrected in the surgical group to $1^\circ \pm 10^\circ$ and was significantly less than in the nonoperative group ($13^\circ \pm 8^\circ$, $P < 0.0001$). As expected, physician, hospital, and total charges were significantly higher in the operative cohort compared to the nonoperative cohort ($P < 0.0001$), accounting for the longer hospital stay, cost of surgery, and implants. The hospital stay in the surgical group was longer than in the nonoperative group (13 ± 7 *vs.* 7 ± 6, $P = 0.001$, Table 2). The higher charges encountered in our report are comparable to those reported in the literature.[7,10] Comparing functional outcomes in terms of VAS and Oswestry Impairment Rating, there was no significant difference between our cohorts (Table 1).

CONCLUSION

From the above review, the selection of treatment in neurologically intact thoracolumbar burst fractures is challenging and should take into account clinical and radiographic criteria. The TLICS classification is indeed helpful; however, 18 of 68 patients with a TLICS score of 2 suffered from pain, requiring early operative rather than nonoperative treatment. The cohort requiring surgery had worse local kyphosis, stenosis, and a higher LSC score than the cohort successfully treated nonoperatively (Table 1). At follow-up, surgical and nonsurgical treatments had similar Oswestry and VAS scores. Delayed kyphosis is less likely following surgical intervention.

➢ Key Points

- ❑ Neurologically intact patients with thoracolumbar burst fractures (TLBF) can be treated successfully without surgery.
- ❑ Failure of nonoperative treatment in TLBS occurred in a quarter of patients with disabling pain, necessitating surgery.
- ❑ Neurologically intact patients undergoing surgery had more kyphosis, stenosis, and vertebral body fragmentation than those treated successfully without surgery.

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