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Clinical Study

# Recurrence of kyphosis and its functional implications after surgical stabilization of dorsolumbar unstable burst fractures

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**Abstract**

**BACKGROUND CONTEXT:** Treatment of unstable burst fractures in the dorsolumbar spine still remains controversial. Surgical stabilization has been aimed to prevent long-term back pain and progression of deformity.

**PURPOSE:** This study was aimed to analyze the degree of loss of correction of the angle of kyphosis with pedicle screw instrumentation in place and the components responsible for the recurrence of kyphosis after surgical stabilization of dorsolumbar A3 fractures and to assess the return of functional capacity in these patients.

**STUDY DESIGN:** Retrospective study.

**PATIENT SAMPLE:** This study involves 26 patients who had dorsolumbar unstable burst fractures (Arbeitsgemeinschaft für Osteosynthesefragen type A3).

**OUTCOME MEASURES:** Radiological assessment at injury, immediate postoperative period, and most recent follow-up along with functional assessment using short form 36 (SF-36) and return to work.

**METHODS:** All the patients had posterior pedicle screw instrumentation without fusion for unstable dorsolumbar burst compression (A3) fractures. The mean follow-up period was 25.5 months. All of them had their fractures stabilized with Universal Spinal System (Synthes, Welwyn Garden City, UK) Fracture System. Serial standing lateral radiographs were taken from the immediate postoperative period to the most recent follow-up. The angle of kyphosis; the heights of the discs above and below the fractured vertebra; and the heights of the vertebral bodies above, at, and below the fractured level were measured. The height at each level was measured in three segments (anterior, middle, and posterior). The values were normalized to avoid discrepancies while comparing radiographs. The difference in the height of each segment measured between the immediate postoperative period and the most recent follow-up was computed.

**RESULTS:** The mean angle of kyphosis was $6.3 \pm 8.9$ in the immediate postoperative period and $15.7 \pm 6.7$ at the most recent follow-up ($p < .001$). The mean patient function score from SF-36 was 52.3%, and the mean pain score was 44.9%. There was no relationship to the loss of correction angle of kyphosis to the patient function score ($r = 0.06$, $p = .76$) and the pain score ($r = 0.11$, $p = .58$). The correlation between the corresponding difference in the height of each segment and the degree of loss of correction of the angle of kyphosis showed positive correlation to the decrease in the anterior and middle segment heights at the fractured vertebral level.

**CONCLUSION:** There is a progressive loss of correction of the angle of kyphosis after posterior stabilization with instrumentation even without implant removal that mainly corresponds to the decrease in the anterior segment height of the fractured vertebral body. © 2009 Elsevier Inc. All rights reserved.

*Keywords:* Thoracolumbar fractures; Burst; Unstable; Surgery; Pedicle screw

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EVIDENCE & METHODS

**Context**
Some centers use short segment posterior stabilization without fusion of thoracolumbar burst fractures. This study aims to assess whether, following reduction and internal fixation, these fractures again ''settle'' into kyphosis.

**Contribution**
Despite the instrumentation, these fractures appeared to lose much of the initial kyphosis correction achieved with surgery. However, the recurrent kyphosis had no impact on pain or functional outcomes.

**Implication**
This study supports previous work suggesting moderate kyphosis (<30°) is often well-tolerated. Furthermore, despite efforts to reduce kyphosis, most fractures will ''settle'' around posterior instrumentation when fusion is not performed. Operative treatment of burst fractures to correct moderate kyphosis as a primary surgical goal without other compelling indications, such as instability or neurological deficit, is of unclear benefit.

—*The Editors*

## Introduction

Unstable burst fractures in thoracolumbar region are common in the young population and produce significant impact on their ability to continue with routine physical activities because of residual deformity and chronic pain [1]. Controversy still exists regarding the management of thoracolumbar burst fractures. Spinal fusion has always been a part of the stabilization procedure; however, it has been already shown in the literature that short-segment pedicle screw fixation without fusion can achieve similar outcome as those with pedicle screw fixation and fusion [2]. Recent literature also questions the significance of transpedicular bone grafting in such cases [3]. Even though pedicle screw instrumentation may achieve better short-segment stabilization, early mobilization, and indirect canal compression, results are not always as predicted. Previous studies have reported recurrence of kyphosis after implant removal [2–8]. Implant removal is not always necessary in these cases [2].

We performed this retrospective study to analyze the degree of loss of correction of kyphosis with the pedicle screw short-segment fixation in place and the contributing factors responsible for the recurrence of kyphosis after surgical stabilization of dorsolumbar burst fractures and to assess the return of functional capacity in these patients.

## Materials and methods

In this retrospective study, we included 26 patients with unstable thoracolumbar burst fractures involving only one segment with no neurological deficit and who underwent a short-segment posterior stabilization without fusion using Universal Spinal System Fracture System (Synthes, UK) between 1998 and 2003. The fractures were classified according to the AO classification for thoracolumbar fractures, originally devised by Magerl et al. [9]. Type A fractures include injuries caused by axial compression and they almost affect the vertebral body exclusively. They were further subclassified as type A1 if they were impaction fractures with compression of cancellous bone with no fragmentation, type A2 if the vertebral body was split sagitally or coronally, and type A3 if the vertebral body was partially or completely comminuted with centrifugal extrusion of fragments (burst fractures). In type A3 fractures, the posterior ligamentous complex should be completely intact. The burst fractures (type A3) are further divided into subgroups, as type A3.1 that include incomplete burst fractures, type A3.2 that include burst-split fractures, and type A3.3 that include complete burst fractures. Type A3.3 fractures are further subgrouped as type A3.3.1 that include pincer burst fractures, type A3.3.2 that include complete flexion burst fractures, and type A3.3.3 that include complete axial burst fractures. Type B fractures include flexion distraction injuries with transverse disruption of the spinal columns. Type C fractures include type A and type B fractures with superimposed rotation and rotational shear injuries. Type A3 (burst fractures) alone were included in this study. In type A3 fractures, surgery was contemplated only if the angle of kyphosis was greater than 30°, anterior body collapse was greater than 50%, or spinal canal compromise was greater than 50%. All the patients had surgery within the first 3 days of injury, and none of them had any postoperative neurological deficit. All the patients had short-segment posterior stabilization performed with transpedicular Schanz screws inserted into the vertebral body above and below the fractured level with no transpedicular bone grafting or posterolateral fusion. Reduction of angle of kyphosis was achieved using the techniques of instrumentation. Universal Spinal System Fracture System was used in all the cases. Postoperatively, the patients were managed with bed rest until trunk control was regained. They were then mobilized with no external support. The implants were not removed routinely. No one in the group required any additional or secondary procedure. All of them had radiographs of thoracolumbar spine before the operation, immediately after operation, and at most recent follow-up. In each radiograph, the angle of kyphosis or Cobb angle was measured by calculating the angle subtended by the tangential line to the superior border of the vertebral body above the injured intervertebral body and the tangential line to the inferior border of the vertebral body below the injured vertebral body (Fig. 1). The heights of the intervertebral discs above and below the fractured vertebra and the heights of the vertebral bodies above, at, and below the fractured level were measured. The height at each level was measured in three segments, namely, anterior, middle, and posterior

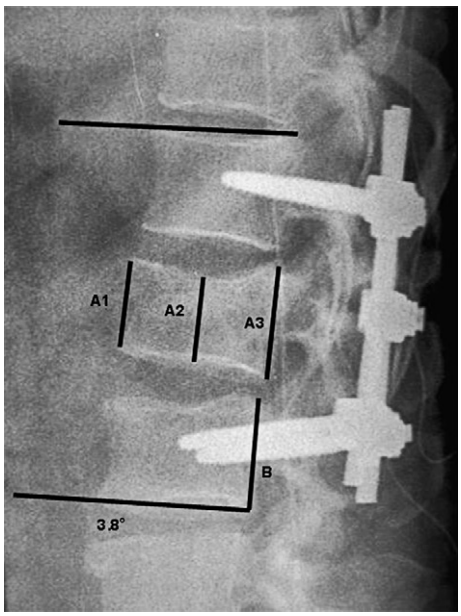


Fig. 1. Lateral radiograph showing the various lines used to measure the Cobb angle (in this case, 3.8°) and the different segmental heights of the fractured vertebral body. The corrected anterior vertebral height (A1) is A1×100/B.

borders. As the segmental height values had to be compared with different radiographs, to negate the effect of the magnification error, the posterior vertebral body height of the vertebra below the fractured vertebra was used as a standard. The segmental height at each level is then expressed as a percentage of the segmental height in relation to the posterior vertebral body height of the vertebra below the fractured vertebra (corrected A1=A1×100/B) (Fig. 1).

At final follow-up, the functional outcome was assessed in terms of physical function and pain using short form 36 (SF-36). The correlation between the final physical function and pain in relation to the final angle of kyphosis as well as in relation to the loss of correction of angle of kyphosis between final follow-up and immediately after surgery was analyzed using Pearson correlation coefficient. The return to work was also noted.

The results were analyzed using SPSS software for Windows, version 11.5 (Chicago, IL, USA). The difference in height of each segment measured during the postoperative period and the most recent follow-up was computed. Relationship between the calculated differences in the segmental height at each level was correlated with the calculated difference in the angle of kyphosis between the immediate postoperative period and the most recent follow-up using Pearson correlation coefficient. A probability value of less than .05 was considered as statistically significant.

## Results

There were 17 men and nine women with a mean age of 42.8 years (range 19–77 years). The mean follow-up was 25.5 months (range 20–31 months). The summary of the descriptive statistics on the segmental heights at different levels at the time of injury, immediately after surgical stabilization, and most recent follow-up is given in Table 1. The angle of kyphosis at different periods is given in Table 2.

Table 1
Segmental heights at each level at injury, immediately after surgery, and at final follow-up

| Mean segmental height after correction (expressed as percentage in relation to posterior segment height of inferior vertebral body) | At injury (%) | Immediately after surgery (%) | At final follow-up (%) |
|---|---|---|---|
| Fractured vertebral body | | | |
| Anterior segment | 52.2 | 63.7 | 52.4 |
| Middle segment | 50.6 | 58.0 | 46.6 |
| Posterior segment | 89.6 | 89.2 | 83.1 |
| Upper vertebral body | | | |
| Anterior segment | 82.3 | 82.8 | 83.4 |
| Middle segment | 77.2 | 79.3 | 73.1 |
| Posterior segment | 92.1 | 92.9 | 90.8 |
| Lower vertebral body | | | |
| Anterior segment | 91.7 | 94.2 | 93.7 |
| Middle segment | 89.2 | 88.0 | 84.5 |
| Posterior segment | 100 | 100 | 100 |
| Superior disc | | | |
| Anterior segment | 14.8 | 22.7 | 10.7 |
| Middle segment | 29.1 | 31.2 | 22.8 |
| Posterior segment | 9.4 | 11.6 | 8.6 |
| Inferior disc | | | |
| Anterior segment | 27.2 | 29.4 | 26.2 |
| Middle segment | 31.9 | 33.6 | 30.2 |
| Posterior segment | 16.1 | 17.5 | 17.8 |

The mean difference in the angle of kyphosis at most recent follow-up compared with that immediately after surgery is −9.4° (range −5° to −20°) (Fig. 2). The correlation between the corresponding difference in the height of each segment and the degree of loss of correction of the angle of kyphosis showed significant correlation to the decrease in the anterior segment height at the fractured vertebral level (r=0.62, p=.01) and also to the decrease in the middle segment height at the fractured vertebral level (r=0.45, p=.02). The other segmental heights at the disc as well as the vertebral body did not correlate with the loss in the angle of kyphosis. However, the mean loss of anterior disc height of the disc above the fractured vertebrae was approaching statistical significance (r=0.32, p=.09), when

Table 2
Angle of kyphosis (Cobb angle)

| Angle of kyphosis | Mean (°) | Minimum (°) | Maximum (°) | SD (°) |
|---|---|---|---|---|
| At injury | 19.6 | 16 | 36 | 8.3 |
| Immediately after surgical fixation | 6.3 | 0 | 14 | 8.9 |
| At follow-up | 15.7 | 5 | 31 | 6.7 |

SD, standard deviation.

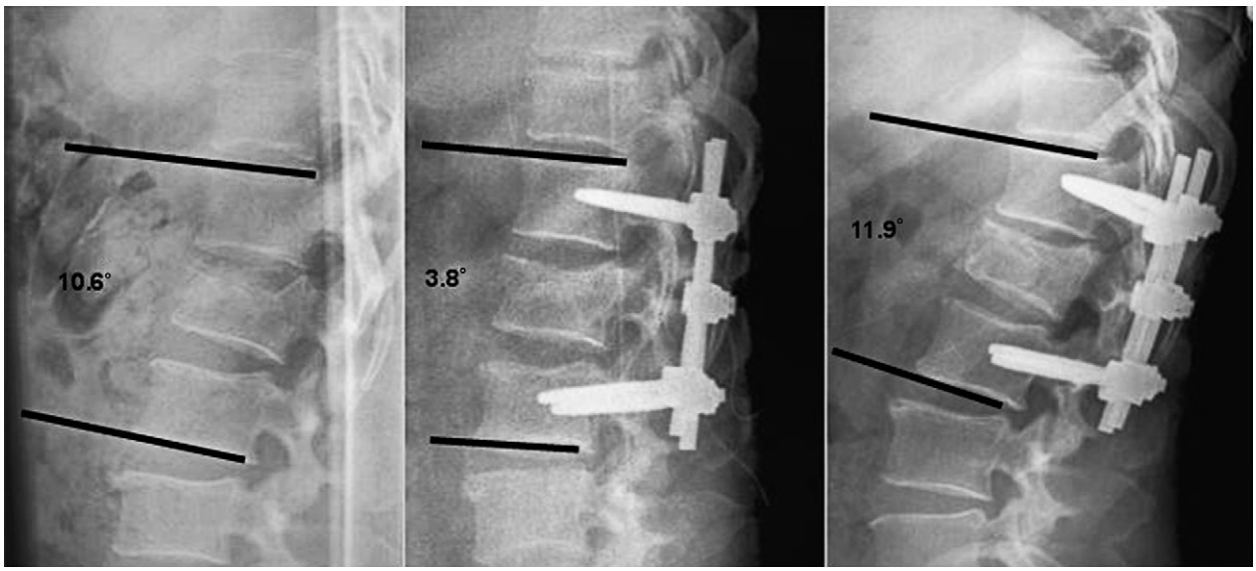


Fig. 2. Lateral radiographs taken at (Left) injury, (Center) immediately after surgery, and (Right) at final follow-up (3 years) showing recurrence of kyphosis.

correlated with loss of angle of kyphosis. The differences in the segmental height at each level at final follow-up and immediately after surgical fixation are given in Table 3.

There was an improvement in the angle of kyphosis immediately after surgery (mean=13.3°; range 4°–26°), which was lost with time. The mean loss of correction showed a statistically significant relationship to the preoperative angle of kyphosis (r=0.46, p=.02).

The mean patient function score from SF-36 was 52.3%, and the mean pain score was 44.9% (Table 4). There was no relationship to the loss of correction angle of kyphosis to the patient physical function score (r=0.06, p=.76) and the pain score (r=0.11, p=.58). There was also no relationship of the loss of correction of angle of kyphosis at final follow-up to the physical function score (r=0.25, p=.16) and the pain score (r=0.24, p=.17). In fact, none of the anatomical parameters had any direct relationship to the functional outcome or pain in these patients. Of 26 patients, only 20 were working before the injury. Fourteen of them returned to work at a mean period of 7.2 months (range

Table 3
Difference in the various segmental heights between final follow-up and immediately after surgery and its relation to the loss of correction of the angle of kyphosis between final follow-up and immediately after surgery

| Difference in segmental height at final follow-up versus after surgery | Mean (%) | SD | Minimum (%) | Maximum (%) | Correlation coefficient (r) | Significance (p Value) |
|---|---|---|---|---|---|---|
| Fractured vertebral body | | | | | | |
| Anterior segment | −11.3 | 9.7 | −31.4 | +7.7 | 0.62 | .01 |
| Middle segment | −11.4 | 13.3 | −38.7 | +14.1 | 0.45 | .02 |
| Posterior segment | −6.1 | 12.3 | −29.1 | +32.5 | 0.21 | .23 |
| Upper vertebral body | | | | | | |
| Anterior segment | +0.7 | 6.4 | −12.0 | +12.5 | 0.07 | .74 |
| Middle segment | −6.2 | 10.4 | −35.5 | +10.3 | 0.23 | .26 |
| Posterior segment | −2.1 | 7.8 | −26.3 | +12.3 | 0.18 | .38 |
| Lower vertebral body | | | | | | |
| Anterior segment | −0.6 | 3.7 | −10.3 | +7.0 | 0.05 | .82 |
| Middle segment | −3.5 | 7.5 | −25.0 | +6.8 | 0.08 | .68 |
| Posterior segment | 0.0 | 0.0 | 0.0 | 0.0 | NA | NA |
| Superior disc | | | | | | |
| Anterior segment | −12.0 | 14.3 | −70.8 | +2.9 | 0.32 | .09 |
| Middle segment | −8.4 | 12.5 | −38.8 | +18.2 | 0.15 | .45 |
| Posterior segment | −3.0 | 6.1 | −20.9 | +9.1 | 0.01 | .96 |
| Inferior disc | | | | | | |
| Anterior segment | −3.1 | 8.7 | −19.2 | +20.0 | 0.22 | .27 |
| Middle segment | −3.4 | 12.7 | −33.0 | +25.0 | 0.15 | .47 |
| Posterior segment | −0.3 | 9.3 | −24.7 | +25.0 | 0.22 | .28 |

SD, standard deviation.

Table 4
Physical function score and pain score at follow-up (SF-36)

| Score (SF-36) | Mean (%) | Minimum (%) | Maximum (%) | SD (%) |
|---|---|---|---|---|
| Physical function | 52.3 | 15 | 100 | 27.3 |
| Pain | 44.9 | 11.1 | 100 | 21.5 |

SF-36, short form-36; SD, standard deviation.

5–12 months), with eight of them to the preinjury level. Six of them were working at a reduced capacity or changed their jobs, whereas six of them stopped working.

## Discussion

Studies in the literature have shown previously that the recurrence of kyphosis in unstable thoracolumbar fractures after short-segment pedicle screw fixation occurs once the implant is removed [2–8]. In our series, we have shown that even if the short-segment pedicle screw fixation is in place, the continued biomechanical forces acting anterior to the construct will eventually produce recurrence of kyphosis. Furthermore, we have shown that it is the fractured vertebral body that loses its anterior and middle segment height, which results in the recurrence of kyphosis. Theoretically, transpedicular bone graft may overcome this problem by filling the large defect in the fractured vertebral body, thereby restoring its height and geometry. However, clinical series have shown that transpedicular bone graft is not effective in preventing recurrence of kyphosis, and essentially, there is no difference clinically whether transpedicular bone graft was used or not when unstable thoracolumbar fractures are stabilized with short-segment pedicle screw fixation [3,4,6].

Our series involved patients who had short-segment instrumentation with no fusion for type A3 burst fractures of the dorsolumbar spine. It may be argued that the loss of angle of kyphosis could be attributed to the lack of fusion. However, the same phenomenon of loss of angle of kyphosis with the final position equivalent to the initial injury had already been shown in the literature in patients with short-segment instrumentation and fusion [10,11].

Some authors believe that the main mechanism for recurrence of kyphosis may be the creeping of the disc back into the central depression of the end plate [8,12]. In our series, even though there is decrease in the middle segment height of the fractured vertebral body, there is significant loss of height of the anterior segment as well. This is compounded further by a decrease in the anterior segment height of the superior disc, which is normally involved in the fracture process. Out of the different segmental heights of the disc above and below the fractured vertebral body, the decrease in the anterior segment height of the superior disc approaches statistical significance than the others. Hence, even though creeping of the disc in the middle segment of the vertebral end plate may play some role in the causation of the recurrence of kyphosis, from our series, it is shown that reduction in the anterior half of the vertebral body with some decrease in the anterior segment of the superior disc also plays a crucial role in the recurrence of kyphosis in unstable thoracolumbar burst fractures treated by a posterior short-segment pedicle screw fixation without fusion. As shown in the literature previously [10], the reduction in height of the anterior segment of the cephalad disc does have a role in contributing to the loss of angle of kyphosis. In our series, there was no statistical correlation between the decrease in the cephalad disc height and the loss in angle of kyphosis. The reason for not reaching the statistical significance may be twofold. One, the number of patients in the study may not be enough to achieve a statistical correlation, and two, the proportion of loss of height of a disc in relation to a vertebra in contributing to the loss of angle of kyphosis is small. However, it approaches statistical significance more than the other radiological parameters in our series.

The segmental heights of the vertebral bodies above and below the fractured vertebral body were also measured and calculated in our series to find whether placing the pedicle screws may weaken the bone or if there was bone bruise at the time of injury that was not recognized may contribute to the future occurrence of kyphosis, or the presence of rigid short-segment pedicle screw fixation may weaken the bones in general because of stress shielding and may result in the recurrence of kyphosis. However, none of the above factors played any role as significant contributing factors in the recurrence of kyphosis in our study.

We also found that final loss of correction of the angle of kyphosis corresponded to the preoperative angle of kyphosis. Previously, Carl et al. [13] had shown that there was a loss of angle of kyphosis with time using posterior pedicle screw instrumentation and fusion with Cotrel-Dubousset system. They showed an average loss of 6.5° of correction of the angle of kyphosis, resulting in only 0.8° of actual final correction of the angle of kyphosis compared with the preoperative angle of kyphosis [13]. In our study, the average loss of the correction of angle of kyphosis is 9.4° that resulted in only 3.9° of actual final correction compared with the preoperative angle of kyphosis. They also showed that 9 of 33 patients had broken or bent pedicle screws. Of the nine patients, two patients had breakage of the screws and seven patients had bent screws. Even though our series did not have any complication, there must be a gentle bend in the rod not evident on plain radiographs to account for the loss of angle of kyphosis. Furthermore, in the study by Carl et al. [13], one patient had ‘‘instrumentation bursitis’’ that needed removal of the metalwork eventually to get rid of the pain. We did not encounter any such complication with the Universal Spinal System implants. As in the previous study [13], we also did not have any neurological complication from pedicle screw placement.

Anterior-only constructs have been used to treat unstable three-column thoracolumbar fractures with good results

[14]. However, these authors performed this procedure only in Arbeitsgemeinschaft für Osteosynthesefragen type B and type C fractures. Biomechanical comparison of anterior-only, posterior-only, and combined anterior and posterior constructs on calf spines showed that superior stabilization was achieved with the combined anteroposterior spinal fixation than a single anterior or posterior construct. Furthermore, there were distinct differences between the anterior-only and posterior-only constructs in stabilizing the spine in different directions of motion [15]. Sasso et al. in 2006 performed a retrospective study comparing 40 patients with anterior-only constructs and 13 patients with posterior-only constructs with short-segment instrumentation for unstable thoracolumbar burst fractures. They found that at final follow-up, the posterior-only constructs lost on an average of 8.1° of the initial corrected angle of kyphosis, whereas the anterior-only constructs lost on an average 1.8° of the initial corrected angle of kyphosis [16].

The loss of correction of the angle of kyphosis did not correlate with the physical function or pain in our series. As shown previously in the literature [2], none of the anatomic parameters measured at any period had any correlation to the final outcome in these patients. The pain score in SF-36 not only assesses the intensity of bodily pain as in SF-20 but also assesses the pain that interferes with normal functional abilities. On comparing the pain score of our patients with the published normative data from a population survey for SF-36 [17], we found that the pain score of our patients belonged to the 25th percentile of social class V on the lower range.

Even though there is recurrence of kyphosis after short-segment fixation of unstable thoracolumbar fractures, there are still advantages in performing them, as the results of conservative treatment may be worse as shown in some series in the literature [2,18]. Furthermore, it is useful in reducing the hospital stay and allows early mobilization, thereby avoiding the risks of long-term recumbency and its associated complications that occur in patients undergoing nonsurgical management. However, as recurrence of kyphosis occurs in thoracolumbar burst fractures treated with short-segment pedicle screw instrumentation, irrespective of whether the implants were removed or not, this opens the previous controversy of the treatment of these fractures. Literature also supports nonsurgical management of these fractures, and the functional outcome between operative and nonsurgical management is not different in some retrospective series [19–23]. A prospective, randomized, controlled trial performed by Wood et al. [24] comparing the operative and nonsurgical management for thoracolumbar burst fractures shows that there is no long-term difference in the functional outcome between the two groups. In fact, the patients in the nonsurgical group had lesser disability than in the operated group. Furthermore, like in our series, the recurrence of kyphosis is noted both in the operative and in the nonsurgical groups to the same extent at final follow-up [24]. Some authors also believe that operative treatment is not essential even if there is ligamentous or bony injury to the posterior column [19,23]. There has been reported improvement in the remodeling of spinal canal with nonsurgical management of these fractures [20].

Our series is limited in that it is retrospective and has limited number of patients. For future studies, a prospective, randomized, controlled trial comparing the recurrence of kyphosis with nonsurgical management and short-segment fixation may be needed to accurately determine the benefit of either method of treatment in unstable thoracolumbar burst fractures.

## Conclusions

There is progressive deformity with recurrence of kyphosis after short-segment pedicle screw fixation without fusion because of the loss of anterior and middle segment heights of the fractured vertebral body. The degree of loss of correction correlates to the preoperative angle of kyphosis and occurs even if the pedicle screw instrumentation is in place. There is no relation to the loss of correction and the patients' functional outcome.

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