

Analysis of the Effect and Prognostic Factors Associated with Postural and Instrumental Reduction in Thoracolumbar Burst Fractures

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ABSTRACT

Background: Axial load on thoracolumbar junction, both mechanical and anatomical transitional zone, causes the compression and flexion of the spine, and consequently thoracolumbar burst fractures.

Objective: This study aimed to investigate the effect and prognostic factors associated with the postural and instrumented reduction on the restoration of vertebral height and kyphosis angle in thoracolumbar burst fractures.

Material and Methods: This retrospective cohort study was conducted on 41 patients with A3, A4, and B type thoracolumbar burst fractures, subjected to postural and instrumented reduction for the restoration of vertebral height and kyphosis angle. The magnitude and correction of kyphotic deformity and percentage of vertebral body collapse were measured before and after postural reduction, and after instrumental insertion to find if they were affected by fracture type and level, time-to-surgery, and use of pedicular screws at the fractured level.

Results: Postural and instrumental reduction significantly improved both the kyphosis angle and the percentage of vertebral body height, regardless of AO types (p.value <0.001 and p.value <0.001, respectively). AO type A3, and A4 comparing to type B, has better restoration of kyphosis angle by postural (p-value=0.013, p-value=0.007, respectively) and instrumental reduction. (p-value=0.006, p-value=0.014, respectively). Evaluation of time to surgery showed that performing operation during the first four days would result in better correction of kyphosis angle (p-value: 0.015).

Conclusion: AO type A3, and A4, time to surgery before 4 days, and fracture level at L2 were favorable prognostic factors to better restoration of kyphosis angle using both postural and instrumented reduction.

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Keywords

Thoracolumbar Burst Fractures; Postural Reduction; Instrumental Reduction; Prognostic Factors; Retrospective Studies; Prognosis; Spine

Introduction

Thoracolumbar junction in the spine plays an important role, both mechanical and anatomical transitional zone [1]. Burst fractures of the spine, based on the definition, are failure of both anterior and middle column of the vertebra as a result of an axial load [2]. This

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injury may cause spinal canal stenosis due to retropulsion of bone fragments. Severe kyphotic deformity, vertebral body collapse, spinal instability, and neurologic deficit are other consequences of this kind of spine fracture [3].

The selection of either nonoperative or operative approach as the appropriate management method in thoracolumbar burst fractures depends on several factors, including the magnitude of kyphotic deformity, the severity of vertebral body height loss, and presence of neurological deficits [1,3,4]. Operations of thoracolumbar burst fractures may be done through anterior, posterior, and combined approaches [4,5]. Postural or manual reduction is usually performed in posterior spine surgery, unless severe spinal canal compromise, delayed time to surgery, and disruption of posterior longitudinal ligament limit its implication [6,7].

Although several large multi-center studies have been conducted to find the optimal treatment of thoracolumbar fractures, they failed to illustrate universal agreement [3]. Given the lack of proof and scarce data on the effects and prognostic factors associated with manual and instrumented reduction in posterior spine surgery, the present study was performed to evaluate the effects and prognostic factors related to postural and instrumental reduction on the restoration of vertebral body height and deformity in patients with thoracolumbar burst fractures, regarding AO fracture type, time to surgery, and vertebral fractured level.

Material and Methods

This retrospective cohort study conducted an analysis of prospectively collected data of 41 patients with thoracolumbar burst fractures, referred to Chamran Hospital, Shiraz, Iran. The patients' demographic data, including age and sex were recorded. Fracture location, fracture type (according to AO classification), fracture level, and time to surgery were documented [5].

Before the operation, the patients' neurolog-

ic exam and computed tomography scans were evaluated to analyze the amount of canal compromise with retropulsed fracture fragments. Only those with intact neurological status and canal compromise <50% were included. Patients with spine fracture above T10 and below L4 level, fracture dislocation, compression fractures, pure anterior column involvement, canal compromise >50%, impaired neurologic status, and medical comorbidities (e.g. diabetes, hypertension, and ischemic heart disease) precluding surgery were excluded from the study.

All patients were operated through the standard posterior approach in prone position by a single orthospine surgeon. To perform the operation, the patient was placed in the prone position with two identical bolsters, one under the breasts, just below the nipples and the other under the iliac crests (Figure 1). Pressure was applied over the apex of the fracture level and lateral X-ray was taken by C-arm fluoroscopy. After exposure of the spine, short instrumentation (1- 2 levels above to 1 level below the fracture site) was performed and the fracture was reduced by distraction or compression according to fracture type. Post-op lateral radiograph was used to measure the instrumented reduction.

The magnitude of kyphotic deformity and its correction, as well as the percentage of vertebral body collapse were measured before and after postural reduction, and after instrumental insertion. Measurements were recorded by three orthopedic surgeons. The AO fracture types, time-to-surgery, the use of screws at the fractured vertebra, and level of the fracture were all checked to find if there is any significant relationship between these variables and the result of postural and instrumental reduction, regarding restoration of vertebral body height and kyphotic deformity.

All data were analyzed by using SPSS software, version 19. Analysis of the quantitative and qualitative data was done through student's t-test and chi-square test, respectively.



Figure 1: Patient position

Kruskal Wallis was employed to find the effect of delay to surgery on the kyphotic correction after postural and instrumental reduction with respect to AO fracture type. $P < 0.05$ was considered to be statistically significant.

Results

Out of 41 enrolled patients, 73.2% and 26.8% were male ($n=30$) and female ($n=11$), aged between 16 and 65 years. The most common involved level was L1 (28.6%, $n=12$) and according to AO classification, 51.2% of fractures were type A4 ($n=21$) (Table 1). The waiting time before surgery ranged from 1 to

13 days, categorized as ≤ 4 days (Group I) and > 4 days (Group II). Group I ($n=23$) was comprised of, 7 (17.1%) cases of A3, 14 (34,1%) cases of A4, and 2 (4.9%) cases of B type fractures. Group II ($n=18$) consisted of 7 (17.1%) cases of A3, 7 (17.1%) cases of A4, and 4 (9.8%) cases of B type fractures. Instrumental fixation was performed by using screw in the involved vertebra in 82.9% of patients ($n=34$) and without screw in 17.1% of patients ($n=7$). The fracture type in those with screw in the involved vertebra was A3 in 14 (34.1%) cases, A4 in 15 (36.5%) cases, and B fracture type in 5 (12.2%) cases. Of those without screw in the

Table 1: Frequencies and percentages of fracture types and levels.

	Variables								
	AO fracture type			Level FX					
	A3	A4	B	T10	T11	T12	L1	L2	L3
Frequency	14	21	6	5	0	8	12	11	5
Percent	34.1	51.2	14.6	12.2	0	19.5	29.3	26.8	12.2

AO: Name of a orthopedic foundation, FX: Fracture

involved vertebra, 6 (14.6%) patients had A4 and 1 (2.4%) had B type fracture.

The mean kyphosis angle was 10.39° before postural reduction, -0.51° after postural reduction, and -4.89° after instrumental reduction. Kyphosis angles of all fracture types (A3, A4, and B) were significantly reduced after postural and instrumental reduction (p.value<0.001). Statistically significant difference, with the Kruskal Wallis test, was observed among the three AO fracture types considering kyphosis angle correction after postural and instrumental reduction (p.value=0.02) (p.value=0.02), respectively (Table 2). Pairwise analysis with Mann Whitney test, showed significant kyphosis angle correction after manual reduction, in AO type A3 and A4 comparing to type B (p-value: 0.013 and p-value: 0.007, respectively). Pairwise analysis with Mann Whitney test showed significant kyphosis correction after instrumental reduction, in AO type A3 and A4 comparing to type B (p-value: 0.006 and p-value: 0.014 respectively).

The mean percentage of vertebral body collapse before and after postural reduction was 37.1% and 21.2%, respectively. It was reduced to 14.7% after instrumental reduction. The percentage of vertebral body collapse reduced significantly after postural and instrumental

reduction in all fracture types (p.value<0.001). The three fracture types were significantly different regarding the percentage of vertebral body height restoration after instrumental reduction (p.value=0.02). Nonetheless, pairwise comparison failed to show any significant differences (Table 2).

Analysis of the effect of time-to-surgery on the degree of fracture reduction (using repeated measurement test) showed that patients who underwent surgery before 4 days, had a significantly better restoration of kyphosis angles compared to patients operated after 4 days (p-value=0.015) (Figure 2). However, it failed to show any significant effect of earlier intervention on restoration of vertebral body height (p-value=0.09).

Mann Whitney test showed the use of screw in the involved vertebra during instrumental reduction had no significant effect on either kyphosis angle correction (p-value=0.97) or vertebral body height restoration (p-value=0.31). This association was also analyzed according to the fracture type, which was not significant in all fracture types.

Each vertebral level has different anatomic characteristics, which may have an effect on the outcome of fracture reduction. After measuring the “quality of reduction” by calculat-

Table 2: Analysis of effect of manual and instrumental reduction on both kyphosis angles and vertebral body collapse regarding different fracture types.

Studied variables	AO fracture type			P-Value	
	Mean (Standard deviation)				
	A3	A4	B		
Kyphosis angle	Baseline	9.18(6.03)	9.26(11.78)	17.15(4.95)	0.09
	After manual reduction	-0.97(8.21)	-3.21(11.63)	10(4.7)	*0.02
	After instrumental reduction	-5.32(7.75)	-7.5(10.99)	5.32(7.97)	*0.02
Vertebral body collapse	Baseline	32.92(10.42)	40.85(12.41)	34.00(17.24)	0.2
	After manual reduction	19.71(8.93)	22.40(9.36)	20.73(13.88)	0.78
	After instrumental reduction	11.00(3.74)	15.61(8.46)	20.50(11.38)	0.02

AO: Name of a orthopedic foundation

*p-value is significant

ing the difference between kyphosis angle and vertebral body height before and after postural and instrumented reduction, significant difference was observed just in the case of instru-

mental reduction compared to the baseline (p-value= 0.03) (Table 3). The level of vertebral fracture had no significant effect on kyphosis angle correction except at L2, showing better

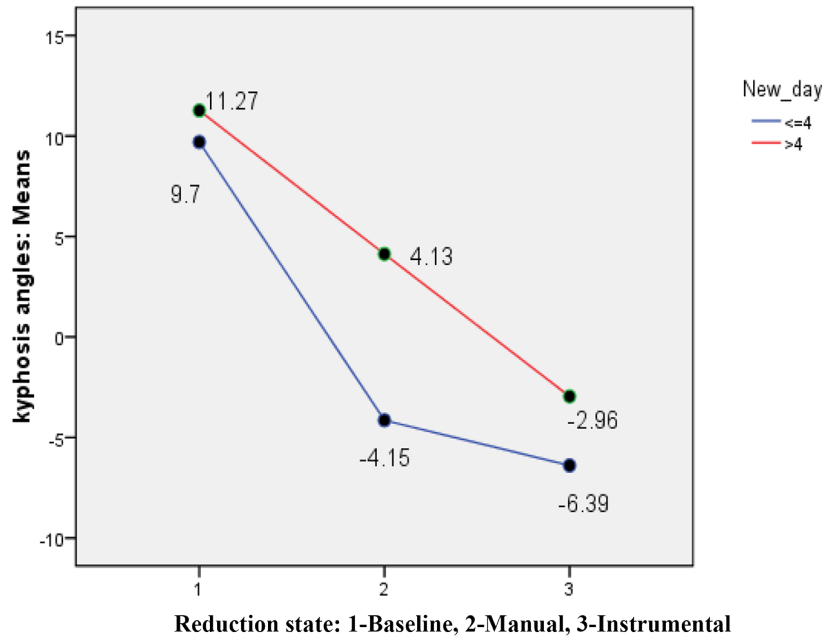


Figure 2: Analysis of effect of days to operations on efficacy of restoration of kyphosis angle regarding manual and instrumental reduction

Table 3: Analysis of effect of manual and instrumental reduction on both kyphosis angles and vertebral body collapse regarding fracture levels.

Studied variables	Level FX					P-Value	
	Mean (Standard deviation)						
	T10	T12	L1	L2	L3		
Kyphosis angle	Delta 1	-2.57(1.61)	-9.33(7.59)	-12.55(5.92)	-12.78(9)	-13.67(8.5)	0.18
	Delta 2	-3.39(3.58)	-5.56(4.89)	-2.81(7.99)	-7.68(8.12)	-3.14(3.99)	0.31
	Delta 3	-5.96(4.56)	-12.89(5.78)	-15.36(6.71)	-20.45(11.07)	-16.82(5.86)	0.03
Vertebral body collapse	Baseline	30.40(14.26)	34.87(14.16)	35.25(13.59)	43.45(8.86)	38.20(14.02)	0.37
	After manual reduction	24.40(8.79)	22.12(7.45)	15.91(10.81)	25.72(10.38)	19.60(5.5)	0.23
	After instrumental reduction	22.20(11.03)	13.50(8.19)	13.00(8.78)	14.18(5.55)	14.80(7.6)	0.2

FX: Fracture

delta 1: Mean of Manual reduction subtracted by Baseline

delta 2: Mean of Instrumental reduction subtracted by Manual reduction

Delta 3: Mean of Instrumental reduction subtracted by Baseline

instrumented reduction at this level.

Height loss measurement was reported as a percentage, therefore there was no need for applying same new measured variable (subtraction mean) as for kyphosis angle for pairwise analysis. No significant association between levels of vertebral fracture and vertebral body restoration was observed (Table 3).

Discussion

Despite several investigations on management of thoracolumbar burst fractures, controversies remains about the optimal surgical approach out of anterior, posterior, or circumferential methods. In the absence of both neurologic involvement and severe spinal canal compromise, posterior approach has the advantage of being more familiar to spine surgeons and fewer complications (e.g. bleeding) compared to the anterior approach. Thoracolumbar burst fractures are the result of axial load, leading to compression and flexion of the spine, which should be reduced with extension and distraction. Thus, postural and instrumental reduction through posterior approach are suggested to indirectly reduce these spine fractures [6,8].

The present study found that postural and instrumental reduction significantly affect the restoration of both vertebral height and kyphotic deformity in A3, A4, and B types of vertebral fractures. Similarly, Cho et al. [9] reported significant improvements in the sagittal index and anterior vertebral height after postural and instrumental reduction. A remarkable finding of the present study was that the effect of both postural and instrumental reduction in correcting kyphosis angle was significantly higher in AO fracture type A3 and A4 compared to type B. Jeon et al. [6] stated burst-split type as a poor prognostic factor for postural reduction, in comparison to other types, including A3 and A4, and we found similar results for AO type B fractures. One possible explanation for this finding is that posterior tension band mechanism remains intact in AO

type A3 and A4. Therefore, applying manual pressure from the back could have better results, restoring the original sagittal angle compared to the B type fractures.

Xu et al. [2] observed that there is no significant difference between the effectiveness of postural reduction and instrumented reduction in the treatment of thoracolumbar burst fractures; however, both reductions are ineffective in patients whose compression of the fractured vertebra is more than two-thirds of the normal. In the current study, the maximum height loss of vertebral fractures was 57%; while, Jeon et al.'s study [6] suggested height loss of more than 50% as a poor prognostic sign for successful postural reduction.

In the present study, the mean kyphosis angle was 10.39° , corrected to -0.51° through postural reduction, and corrected to -4.89° through instrumental reduction. The mean percentage of vertebral body collapse was 37.1% in the baseline, corrected to 21.2% after postural reduction, and 14.7% after instrumental reduction. Compared to our study, Yang et al. [4] achieved better results by instrumental reduction in the restoration of vertebral height and Cobb angle as they reported correction of the anterior height from 57.9% to 99.0% and Cobb angle from 18.4° to 0.17° . Jeon et al. [6] reported that postural and instrumental reduction was significantly effective in kyphosis angle restoration (66% and 34%, respectively) and vertebral height recovery (44% and 56%, respectively). They conclude that postural reduction is more important in sagittal correction while instrumentation was more important in coronal reduction [6].

The current study showed that instrumental reduction is more effective in restoration of kyphosis angle at L2 level of fracture. However, Seo et al. [1] failed to show any significant association between fracture level and favourable outcomes regarding kyphosis angle correction. The finding of our study could be explained by the fact that L2 level is closer to the apex of lumbar lordosis and instrumented

reduction may be more effective at this level.

In the current study, we also found that it is more effective to perform postural and instrumental reduction during first 4 days regarding correction of kyphotic deformity, but failed to be effective in restoration of vertebral body height. Similarly, Jeon et al. [6] mentioned more than 3 days delay time for the operation as a significant factor in insufficient postural and instrumental reduction [6]. Sjöström et al. [10] asserted that indirect reduction was effective when performed in <50% canal compromise and within 2 days [10].

One of the important limitations of this study was the small sample size. Moreover, we failed to evaluate bone mineral density, which could influence the amount of postural and instrumental reduction, and also meticulously failed to evaluate suspicious posterior longitudinal ligament disruption due to the lack of magnetic resonance images, which is of great importance in the selection of the appropriate surgical approach. On the other hand, prospective nature of this study was its strength, leading to achieving more accurate and reliable results. Other strong points of this study were the computation of the measurements details during postural and instrumental reductions in posterior surgical approach, and performing postural and instrumented reduction by the same instruments and a single orthospine surgeon. Further studies with larger sample size are required to achieve more quality and scientific evidence.

Conclusion

Based on the study findings, it can be concluded that postural and instrumental reduction both have a significant effect on the restoration of vertebral kyphosis angle and vertebral height in the thoracolumbar burst fractures. Novel finding of our study is that, kyphosis angle in AO type A3 and A4, is more effectively corrected by postural and instrumental reduction, compared to type B fractures. The other favourable prognostic factors associ-

ated with better correction of the kyphotic deformity through postural or instrumental reduction, are the time of surgery before 4 days and fracture level at L2.

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Conflict of Interest

None

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