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Original Article

Correlations between repositioning of bone fragment in thoracolumbar burst fractures and size of bone fragment, and AO classification

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Abstract: Background: The reposition of bone fragment is important in the treatment for thoracolumbar burst fractures, but it is not clear whether there are correlations between the reposition of bone fragment and the size of bone fragment, and AO classification in the thoracolumbar fractures. Materials and methods: Forty-two patients were divided into two groups according to whether reposition of bone fragments (Reposition group) or not (Non-reposition group). There were 17 patients in the reposition group and 25 patients in the non-reposition group. All the fractures were classified according to the AO classification system. Neurological status was classified according to American Spinal Injury Association (ASIA) grading. The height and width of bone fragments (HBF and WBF) were measured. Then ratio of height of bone fragment occupying height of posterior wall of vertebrae body (RHBF) and ratio of width of bone fragment occupying transverse canal diameter (RWBF) were calculated. Spearman correlation coefficients were used to evaluate relationships between reposition of bone fragments and those parameters, AO classification. Results: There was a significant difference on the HBF (t=-3.518, P=0.001<0.05), WBF (t=-3.312, P=0.002<0.05), RHBF (t=-2.828, P=0.007<0.05) and RWBF (t=-4.164, P=0.000<0.05) between the two groups. There were significant positive correlations between reposition of bone fragments and AO classification (r=0.569, P<0.01), and RWBF (r=0.429, P<0.01), and RHBF (r=0.361, P <0.01), and HBF (r=0.326, P<0.05), and WBF (r=0.305, P<0.05). Conclusion: AO classification, HBF, WBF, RHBF and RWBF are predictive of reposition of bone fragments in thoracolumbar burst fractures and correlated to reposition of bone fragments.

Keywords: Thoracolumbar burst fractures, bone fragments, reposition, AO classification, size

Introduction

Ninety percents of spinal fractures occur in the thoracolumbar region, and burst fractures contribute to approximately 10-20% of such injuries [1-4]. It is one of the most common causes for spinal cord injury. In all thoracolumbar burst fractures the frequency of neurological deficits can reach up to 50-60% [4-6]. Spinal cord injury includes both primary and secondary injury mechanisms [2, 7]. Secondary injury caused by compression of bone fragments and lead to a series of pathophysiologic changes, such as 1) vascular changes [7, 8]; 2) electrolyte shift [9, 10]; 3) neurotransmitter accumulation [11-13]; 4) arachidonic acid release [14-16]; 5) endogenous opioids [17, 18]; 6) edema formation [19]; 7) inflammation; and 8) loss of energy metabolism [20]. Fortunately, reposition of bone fragments could avoid aggravating the secondary injury.

Anterior and posterior are two approaches in the spinal surgery. Posterior surgery was recommended to use in emergency neurode compression and fix unstable thoracolumbar fractures, since it could shorten operation time and reduce blood loss versus anterior surgery [21-25]. Lordosation and distraction with the internal fixator lead to the restoration of the height, kyphosis correction and in many cases widening canal by the phenomenon of ligamentotaxis in the posterior surgery [26]. Ligamentotaxis is primarily induced by increased tension on the posterior longitudinal ligament during lordosation and distraction. The volume of the fractured vertebra increase rapidly during this procedure. This may contribute to the effect of liga-

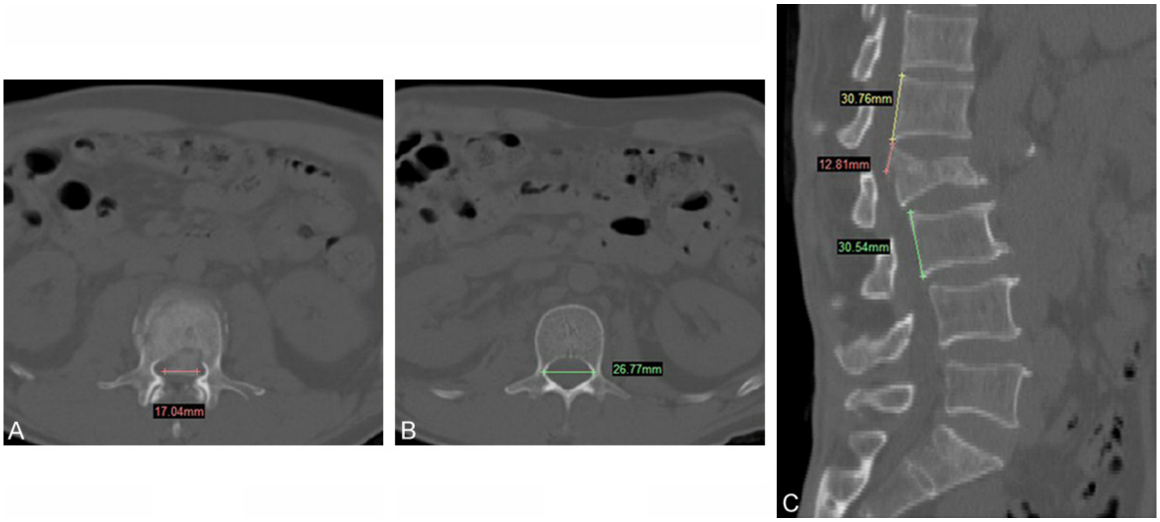

Figure 1. A. The width of bone fragment was 17.04 mm; B. The transverse canal diameter was 26.77 mm. C. The heights of posterior vertebral wall above and below the injury vertebral were 30.76 mm and 30.54 mm. The height of bone fragment was 12.81 mm.

mentotaxis which generated the area under pressure, however it inducing suction on the dislocated bone fragments [27].

Although the ligamentotaxis plays an important role in the restoration of bone fragments, not all the bone fragments can be repositioned in the posterior surgery. According to the study [27], the non-reposition of bone fragment may be due to the degree of instrumental lordosation, variation of the shape of the dislocated fragments and frequency, and the extent of damage of posterior longitudinal ligament. But there are few studies about the correlations between the reposition of bone fragments and the characteristic of bone fragments [28], AO classification, and ASIA grading. This study aims to determine the correlations between the reposition of bone fragment and the size of bone fragment, AO classification, and ASIA grading.

Materials and methods

We retrospectively reviewed consecutive patients with a thoracolumbar (T_{11}-L_2) burst fracture from a single center [29] (from 2009 to 2013). Inclusion criteria include: 1) patient with single vertebrae thoracolumbar burst fractures because of trauma; 2) patient was examined by multi-planar computed tomography (CT) scan before and after surgery; 3) surgery was implemented within a week and 4) posterior longitudinal ligament was intact according to the MRI image. The patients who conform to the above four criteria were taken into this study. Mimics10.01 measures the relevant parameters.

Axial-plane central canal measurements

The width of bone fragment (WBF, **Figure 1A**) was defined as width of bone fragment at the vertebral pedicle level of CT image. Transverse canal diameter (TCD, **Figure 1B**) was defined as distance between the medial borders of the pedicles at the mid-pedicle level. All measurements were measured directly with Mimics10.01.

The ratio of width of bone fragment occupying transverse canal diameter (RWBF) was calculated according to formula V2/(V1 + V3)/2.28 V1 indicates the TCD above the injury vertebra. V2 indicates width of bone fragment. V3 indicates TCD below the injured vertebra.

Sagittal-plane central canal measurements

The height of bone fragment (HBF, **Figure 1C**) was defined as height of bone fragment at the mid-sagittal plane of the CT image. Height of posterior wall of injury vertebral body was calculated according to formula (V1 + V3)/2.28, 29 The ratio of height of bone fragment occupying posterior wall of injury vertebral body (RHBF) was calculated according to formula V2/(V1 + V3)/2.28, 29 V1 indicates the height of vertebra at the level above the injury vertebra. V2

Table 1. Patient information

Patient information	Position of Bone fraction (n)	ASIA grading (n)
Male (26)	T11 (4)	ASIA A (12)
Female (16)	T12 (8)	ASIA B (7)
Mean age (38.8±23.7)	L1 (18)	ASIA C (4)
	L2 (12)	ASIA D (4)
		ASIA E (15)

Table 2. The AO classification and ASIA grading for Reposition and Non-Reposition group

AO Classification	Number	Reposition	Non-reposition
A3.1	12	10	2
A3.2	13	3	10
A3.3	17	4	13

indicates height of bone fragment. V3 indicates height of vertebral at the level below the injured vertebra. V1, V2 and V3 were measured directly with Mimics10.01 assistance.

Fracture pattern and neurological injury

All the fractures were classified according to the AO classification system [30]. A1 is compression fracture. A3 is burst fracture. A3.1 is wedge compression fracture. A3.2 is sagittal or coronal split fracture in the vertebral body. A3.3 is comminuted and displacement fracture.

The neurological status was classified according to American Spinal Injury Association's modified Frankel's grading of traumatic paraplegia: 30 A, No sensory or motor function is preserved in the sacral segments S4-S5; B, Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5; C, Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3; D, Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade greater than or equal to 3; and E, Sensory and motor function is normal. As the fractures pattern is sequentially classified into three subgroups and neurological injury is classified into five types, the values are added to provide a comprehensive severity score. A3.1 is assigned 1 point, A3.2 is assigned 2 points and A3.3 is assigned 3 points.

Indications for surgery and status of bone fragments

Indications for surgery were loss of vertebral body height greater than 50% or kyphosis greater than 20°. All the patients underwent posterior surgery with posterior fixations (USS fracture, Depuy-Synthes, USA). Alignment of posterior vertebral wall was criteria for assessing the status of bone fragments after surgery. Reposition was assigned 1 point, while non-reposition was assigned 2 points.

Assessment of bone fragment reposition

According to the research [31] the continuous and smooth posterior vertebral body line imaging is a simple and effective method to judge the reduction of a bone fragment retropulsed into the spinal canal. It can provide evidence as to whether a laminectomy and pushing the bone fragment are necessary during posterior surgery.

Statistical analysis

We used SPSS 12.0 for windows (SPSS Inc, Chicago, Illinois) for statistical analysis. All data were presented as mean ± standard deviation (SD) or frequency. Spearman correlation between the reposition of the bone fragments and parameters about the size of bone fragment, and AO classification was analyzed. All tests were set as two tales and a *P* value of <0.05 was considered statistical significant.

Results

Included patients

A total of 42 patients constituted the study population. The demographics of the patients are shown in **Table 1**. There were 17 patients with reposition of bone fragment and 25 patients with non-reposition of bone fragment after surgery. The numbers of reposition and non-reposition of bone fragments in different AO classification and ASIA grading are shown in **Table 2**.

Measurements of parameters

Summary of CT measurements (mean, standard deviation) are shown in **Table 3** for each measurement. The minimal HBF was 6 mm in the reposition group, while 8 mm in the non-

Table 3. Summary of measurements about size of bone fragments

	Reposition		Non-reposition		P
	Mean	SD	Mean	SD	
Height of bone fragments (mm)	10.77	3.18	13.96	2.58	0.001
Width of bone fragments (mm)	14.63	2.88	18.58	4.77	0.002
RHBF (%)	0.376	0.115	0.478	0.118	0.007
RWBF (%)	0.528	0.157	0.756	0.198	0.000

RHBF: ratio of height of bone fragment; RWBF: ratio of width of bone fragment.

Table 4. Correlation between reposition of bone fragments and parameters of size of bone fragments, and AO classification

	r	P
HBF	0.326	0.010
WBF	0.305	0.016
RHBF	0.361	0.004
RWBF	0.429	0.000
AO Classification	0.569	0.000

HBF: height of bone fragment; WBF: width of bone fragment; RHBF: ratio of height of bone fragment occupying height of posterior wall of vertebrae body; RWBF: ratio of width of bone fragment occupying width of transverse canal diameter.

reposition group. The minimal WBF was 9 mm in the reposition group, while 11 mm in the non-reposition group. The minimal RHBF were 27.1% and 32.8% respectively in the reposition group and the non-reposition group. The minimal RWBF was 41.8% in the reposition group which smaller than the 55.7% in the non-reposition group.

Correlations between reposition of bone fragments and different parameters measurements, and AO classification

There was significant difference on HBF, WBF, RHBF and RWBF between the reposition group and non-reposition group (**Table 3**). As demonstrated in **Table 4**, there were significant positive correlations between reposition of bone fragments and AO classification (r=0.569, P<0.01), and RWBF (r=0.429, P<0.01), and RHBF (r=0.361, P<0.01), and HBF (r=0.326, P<0.05), and WBF (r=0.305, P<0.05).

Discussion

These results demonstrate that AO classification, ASIA grading HBF, WBF, RHBF and RWBF are associated with reposition of bone fragments.

Reposition of bone fragments has been established to be associated with ligamentotaxis by intact posterior longitudinal ligament. Ligamentotaxis can reduce only those retropulsed fragments which are still attached to ligamentous structures [26]. Currently, MRI is considered as the "gold standard" to determine the posterior longitudinal ligament injury in thoracolumbar burst fracture. It has been found to be sensitive to posterior longitudinal ligament injury reasonably, even though it may not discriminate all the posterior longitudinal ligament status [32]. So in this study we retrospectively reviewed the medical charts of patients with thoracolumbar burst fractures and intact posterior longitudinal ligament into study.

Nowadays, researchers found that large trapezoid-shaped fragments are difficult to reposition by ligamentotaxis [27]. But it is not clear whether the size of bone fragments affect the reposition of bone fragments. In this research we took the size of bone fragments into study to determine the correlations between reposition of bone fragments and those influence factors. The results indicated that HBF, WBF, RHBF and RWBF were related to the reposition of bone fragments. Especially the RHBF and RWBF were closely correlated with the reposition of bone fragments.

AO classification is always used to assess the severity of thoracolumbar burst fractures. And ASIA grading is used to estimate the severity of nerve injury. They are important evaluating parameters for thoracolumbar burst fractures before treatment. But it was not clear whether they were related to evaluate the reposition of bone fragments thoracolumbar burst fractures before the treatment. We took AO classification and ASIA grading into account. The results suggest that AO classification was positive correlation with reposition of bone fragments, while ASIA grading was negative correlation. Patients with severe bony destruction might be expected to have higher degree AO classification and poor ASIA grading due to the greater crush of vertebral body. Meanwhile the bone fragments are difficult to be repositioned. Conversely, patients with subtle bony destruction have lighter degree AO classification and better ASIA grading, the bone fragments are easy to be repositioned. In addition, AO classification and ASIA grading showed higher correlation coefficient than HBF, WBF, RHBF and RWBF. It indicated that AO classification and ASIA grading were more important parameters compared with the size of bone fragments for assessing the reposition of bone fragments before the treatment of thoracolumbar burst fractures.

Strengths of this study include analyzing multiple parameters that are correlation to the reposition of bone fragments and revealing the most important referential parameters. At the same time this study reminds surgeon pay attention on parameters about assessing reposition of bone fragments before operation. Limitations of this study include that sample is small.

Conclusion

These results demonstrate that AO classification, ASIA grading, HBF, WBF, RHBF and RWBF are correlations to reposition of bone fragments in the thoracolumbar burst fracture. But the AO classification and ASIA grading are apparently more important than others. It is necessary to pay attention to the AO classification and ASIA grading before surgery. Certainly surgeons should consider direct assessment of reposition of bone fragment at the intra-operation. However, limitations of this study are its single-center retrospective nature and the small number of samples. A long-term follow-up of a prospective cohort is needed in the future to confirm the present results.

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Disclosure of conflict of interest

None.

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