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Original Article

Correlation of bone fragments reposition and related parameters in thoracolumbar burst fractures patients

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Abstract: The aim of this study is to determine if thoracolumbar vertebral body collapse or canal compromise (CC) is associated with reposition of bone fragment. We retrospective review medical charts of patients with thoracolumbar burst fractures from July 2010 to September 2013. The fractures were classified according to the Arbeit Fuer Osteoosynthese (AO) classification system. Neurological status was classified according to American Spinal Injury Association (ASIA). Patients were divided into two groups (reposition group and non-reposition group) according to whether the bone fragments were reposition or non-reposition after surgery. Mimics measured mid-sagittal canal diameter (MSD), transverse canal diameter (TCD), local kyphosis (LK) and calculated anterior vertebral body compression ratio (AVBCR), middle vertebral body compression ratio (MVBCR), posterior vertebral body compression ratio (PVBCR), and mid-sagittal canal diameter compression ratio (MSDCR) on the preoperative CT image. The results indicated that 55 patients were included in the study. There are 35 patients with reposition of bone fragment and 20 patients with non-reposition of bone fragment after surgery. There were significant difference on MSD ($t = 3.258$, $P = 0.002$), TCD ($t = 2.197$, $P = 0.032$), AVBCR ($t = -2.063$, $P = 0.044$), MVBCR ($t = -2.526$, $P = 0.015$), PVBCR ($t = -2.211$, $P = 0.031$), MSDCR ($t = -4.975$, $P = 0.000$) between two groups before surgery. There was a significant correlation between reposition of bone fragment and AO classification ($OR = 5.251$, $P = 0.022$), and MSDCR ($OR = 7.366$, $P = 0.007$). There was no significant correlation between reposition and AVBCR, MVBCR, PVBCR, LK, MSD and TCD. In conclusion, this study indicates that AO classification and MSDCR are predictors of reposition of bone fragment.

Keywords: Thoracolumbar burst fractures, bone fragments, canal compromise, kyphosis, vertebrae body height

Introduction

Ninety percent of all 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, and the frequency of neurological deficits in all thoracolumbar burst fractures can reach up to 50-60% [4-6]. Spinal cord injury includes both primary and secondary injury mechanisms [2, 7]. Secondary injury because of compression of bone fragments lead to a series of pathophysiologic changes such as ① vascular changes including reduction in blood flow, loss of auto-regulation, neurogenic shock, hemorrhage, loss of microcirculation, vasospasm and thrombosis [7, 8]; ② electrolyte shifts including increased intracellular calcium, increased extracellular potassium, and increased sodium permeability [9, 10]; ③ neurotransmitter accumulation such as serotonin or catecholamines [11] and extracellular glutamate [12], the latter producing excitotoxicity [13]; ④ arachidonic acid release, free radical production especially oxygen-free radicals [14], eicosanoid production, especially prostaglandins, and lipid per-oxidation [15, 16]; ⑤ endogenous opioids [17, 18]; ⑥ edema formation [19]; ⑦ inflammation; and ⑧ loss of energy metabolism, especially decreased adenosine triphosphate production [20]. So reposition of bone fragments by ligamentotaxis is benefit to recovery of neurological function.

Ligamentotaxis in the posterior surgery can be recommended in emergency neuro-decompression and fixation of unstable thoracolumbar fractures because of the shorter operation time and smaller blood loss versus anterior surgery [21-25]. Lordosation and distraction with the

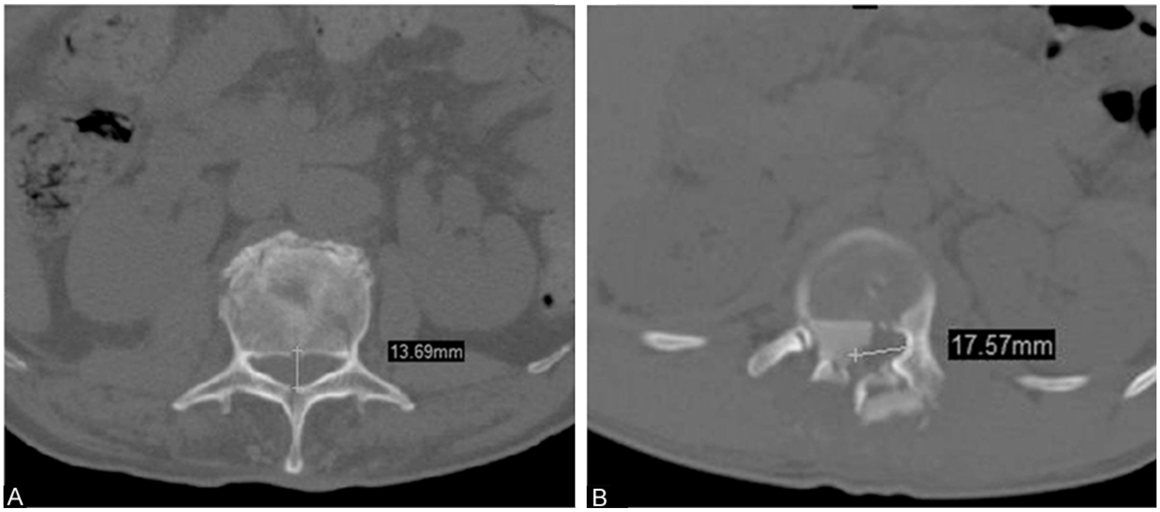

Figure 1. The axial CT images for mid-sagittal diameter and transverse canal diameter. A. The Mid-sagittal diameter was 13.69 on the axial CT image. B. The transverse canal diameter was 17.57 mm on the axial CT image.

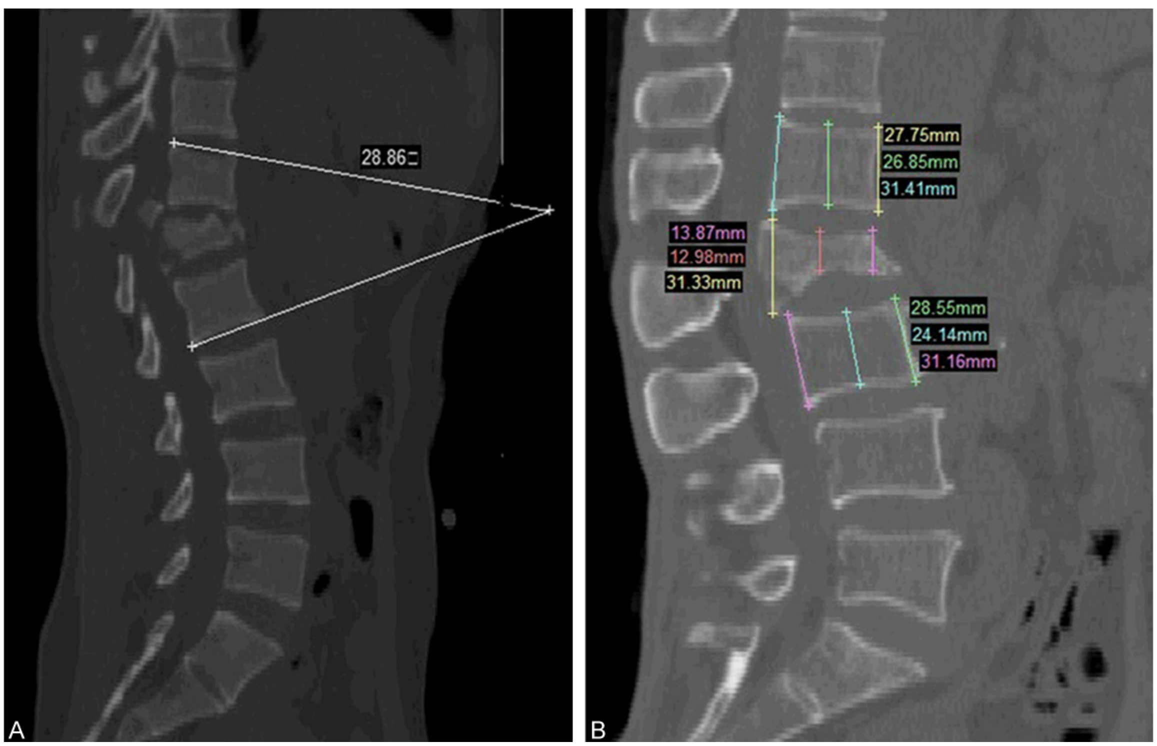

Figure 2. Mid-sagittal CT images. A. The kyphosis was 34.68° on the mid-sagittal CT image. B. Heights of Anterior, middle, and posterior wall of injury vertebrae and vertebras above or below the injury vertebra on the mid-sagittal CT image.

internal fixator lead to the restoration of height, kyphosis correction and in many cases to canal widening by the phenomenon of ligamentotaxis. Ligamentotaxis is primarily induced by increased tension on the posterior longitudinal ligament during lordosation and distraction. The rapid volume increase of the fractured vertebra during this procedure may contribute to the effect of ligamentotaxis by creating an area of under pressure, inducing suction on the dislocated bone fragments. But ligamentotaxis rely on intact PLL. Although magnetic reso-

Table 1. Demographics characteristic of 55 patients with thoracolumbar burst fractures

Characteristics	Value	*P*
Gender		0.021*
Male	35	
Female	20	
Mean age (yr)	39.2	
Thoracolumbar		0.042*
T11	4	
T12	12	
L1	23	
L2	16	
ASIA grade		0.054
ASIA A	12	
ASIA B	10	
ASIA C	8	
ASIA D	5	
ASIA E	20	
Fall	32	
MVA	23	
AO classification		0.071
A3.1	20	
A3.2	17	
A3.3	18	

*P<0.05 represents the difference among the characteristics.

nance imaging (MRI) is used to diagnose PLL status, it is not clear that correlation between multiple radiographic parameters, AO classification, ASIA grade and PLL status. This study discriminated if multiple parameters correspond to reposition of bone fragments.

Materials and methods

We retrospectively reviewed consecutive patients with a thoracolumbar (T_{11}-L_2) burst fracture from a single center. Inclusion criteria include consecutive patients with single vertebrae thoracolumbar burst fractures because of trauma. Exclusion criteria include pathological fractures, multiple vertebras thoracolumbar burst fractures and osteoporosis. Patients were examined by multiplanar computed tomographic (CT) scan before surgery. All the patients underwent spinal surgery with the same posterior instrumentation.

Axial-plane central canal measurements

Mid-sagittal canal diameter (MSD, **Figure 1A**) was defined as distance between the posterior canal border and anterior canal border. 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 Mimics 10.01 (Materialise Corporation, Belgium) assistance.

Mid-sagittal canal diameter compression ratio (MSDCR) were calculated according to formula $[(V1 + V3)/2 - V2]/(V1 + V3)/2$ [26]. V1 indicates MSD of the spinal canal above the injury. V2 indicates MSD at the injured level. V3 indicates MSD at the level below the injured vertebra. V1 and V3 were measured directly with Mimics 10.01 (Materialise Corporation, Belgium) assistance.

Sagittal-plane central canal measurements

Local kyphosis was defined as angle formed between a line drawn parallel to the superior endplate of 1 vertebra above the fracture and a line drawn parallel to the inferior endplate of the vertebra 1 level below the fracture [27] (LK, **Figure 2A**). All measurements were measured with Mimics 10.01 (Materialise Corporation, Belgium) assistance.

The heights of anterior, middle and posterior wall of vertebrae body were measured with Mimics 10.01 (Materialise Corporation, Belgium) assistance (**Figure 2B**). Anterior vertebral body compression ratio (AVBCR), middle vertebral body compression ratio (MVBCR), posterior vertebral body compression ratio (PVBCR) were calculated according to formula $[(V1 + V3)/2 - V2]/(V1 + V3)/2$ [26, 28]. V1 indicates the height of vertebra at the level above the injury vertebra. V2 indicates height of injured vertebra. V3 indicates height of vertebral at the level below the injured vertebra. V1, V2 and V3 were measured directly with Mimics 10.01 (Materialise Corporation, Belgium) assistance.

Assessment of the reposition of bone fragments

CT assessed reposition of bone fragments by posterior instruments after surgery. Reposition is assigned 1 point. Non-reposition is assigned 2 points.

Fracture pattern and neurological injury

All the fractures were classified according to the AO classification system. A1 is compression

Table 2. Summary of Mimics 10.01 measurements

	Reposition group (n = 35)		Non-reposition group (n = 20)		*P*
	Mean	SD	Mean	SD	
Anterior vertebral body compression ratio (%)	0.21	0.146	0.292	0.134	P<0.05*
Middle vertebral body compression ratio (%)	0.217	0.095	0.301	0.152	P<0.05*
Posterior vertebral body compression ratio (%)	0.112	0.123	0.188	0.122	P<0.05*
Mid-sagittal canal diameter compression ratio (%)	0.306	0.181	0.599	0.254	P<0.05*
Local kyphosis (°)	9.07	4.97	9.48	4.67	P<0.05*
Mid-sagittal canal diameter (mm)	11.13	3.18	7.83	4.28	P<0.05*
Transverse canal diameter (mm)	24.82	2.82	20.21	11.92	P<0.05*

t test was used to analyze the statistical differences between groups. *P<0.05 represents the different comparison between groups.

Table 3. The numbers of reposition and non-reposition of bone fragments in different AO classifications

AO Classification	Number	Reposition	Non-reposition
A3.1	20	18	2
A3.2	17	10	7
A3.3	18	2	16

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 [29]: 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.

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. Logistic Regression correlates different parameters, AO classification, ASIA grade, and reposition of bone fragment. The t test and Chi square test were used in for the comparison of the AO classification, ASIA grade, reposition of bone fragment. All tests were set as two sides and a *P* value of <0.05 was considered statistical significant.

Results

There 55 patients formed the study population. The demographics of the patients are presented in **Table 1**. Mean age was 39.2 years. There were 35 men and 20 women. Summary of CT measurements (mean, standard deviation) is displayed in **Table 2** for each measurement. The minimal mid-sagittal canal diameter (MSD) is 0. The minimal transverse canal diameter (TCD) is 0. The maximal anterior vertebral body compression ratio (AVBCR), middle vertebral body compression ratio (MVBCR) and posterior vertebral body compression ratio (PVBCR) were 55.3%, 47.2% and 41.9%. The maximal local kyphosis (LK) angle was 45.71°. The maximal mid-sagittal canal diameter compression ratio (MSDCR) was 100%. The numbers of reposition of bone fragment in different AO classification are displayed in **Table 3**. There were 30 patients with reposition and 25 patients with non-reposition after surgery.

Table 4 displays coefficients between different parameters, AO classification and reposition of bone fragment. There was a significant correlation between reposition of bone fragment and MSDCR (OR = 7.366, P = 0.007), AO classification (OR = 5.251, P = 0.022). There was no significant correlation between measurements of

Table 4. Correlation between reposition of bone fragment and parameters

	OR (95% CI)	P
Anterior vertebral body compression ratio	1.359 (0.431-1.732)	0.244
Middle vertebral body compression ratio	1.723 (0.524-2.312)	0.189
Posterior vertebral body compression ratio	1.314 (0.402-1.649)	0.252
Mid-sagittal canal diameter compression ratio	7.366 (4.583-11.321)	0.007*
Local kyphosis (°)	2.369 (1.453-5.483)	0.124
Mid-sagittal canal diameter (mm)	3.758 (3.674-8.32)	0.053
Transverse canal diameter (mm)	0.027 (0.011-2.04)	0.869
AO Classification	5.251 (3.982-10.023)	0.022*

Footnote: *P<0.05 represents the statistical values of the OR (95%).

LK, AVBCR, MVBCR, PVBCR, MSD, TCD and reposition of bone fragment (**Table 4**).

Discussion

These results demonstrate that LK, AVBCR, MVBCR, PVBCR, MSD and TCD are not associated with reposition of bone fragment. AO classification and MSDCR were found to be related to that.

Loss of vertebral body height greater than 50% or kyphosis greater than 20°was indications for surgery. But Loss of vertebral body height was just expert opinion and not a determinant of clinical outcome [2, 30-35]. Kyphosis greater than 20° is associated with spinal instability [31]. MSDCR was associated with neurological deficiency. But those parameters were not found to correlate to the reposition of bone fragment.

These findings suggest that spinal canal compromise, AO classification and ASIA grade could be predictors of assessing reposition of bone fragment. Patients with severe bony destruction might be expected to have higher degree AO classification, ASIA grade, spinal canal compromise and loss of vertebral posterior height because the vertebral body had a greater crush, the bone fragment may be difficult to reposition. Conversely, patients with subtle bony destruction have lighter degree AO classification, ASIA grade, spinal canal compromise and loss of vertebral posterior height, the bone fragment may be easy to reposition.

Strengths of this study include it analyze multiple parameters that are correlation to the reposition of bone fragments and point out the most important referential parameters. At the same time this study reminds surgeon attention on necessary parameters about assessing reposition of bone fragment before operation. Limitations of this study include that sample is small and it did not acquire quantized numeric.

In conclusion, these results demonstrate that MSDCR and AO classification are correlations to reposition of bone fragment in the thoracolumbar burst fracture. Especially reposition of bone fragment is not clear during surgery, it is necessary that paying attention to the MSDCR and AO classification. Certainly surgeons should consider direct assessment of reposition of bone fragment if there is clinical concern instead of indirect assessment from radiography measurements.

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Disclosure of conflict of interest

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