Impact of short segment fixation on Spinopelvic Sagittal Alignment in Thoracolumbar Fracture Cases

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Article

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Abstract

Background: Previous studies have reported the impact of thoracolumbar kyphosis induced by spinal burst fracture on spinopelvic sagittal alignment. But no study has analyzed the effects of short segment fixation on spinopelvic parameters in patients with spinal burst fracture. Thus, this study aimed to explore the impact of short segment fixation on spinopelvic sagittal alignment in patients with thoracolumbar fractures.

Methods: Perioperative radiographs of 42 patients with thoracolumbar fractures treated with short-segment fixation surgery were obtained. The pelvic and spinal parameters were measured, and the influence of fracture site on all parameters was retrospectively analyzed. A descriptive analysis characterizing these parameters and multivariate analysis was performed to investigate the influencing factors of thoracolumbar kyphosis.

Results: The mean age of included cases was 47.1±9.9 years, Pelvic incidence(PI) was 44.1±4.7º. Preoperative fractured level kyphosis (FLK) and thoracolumbar kyphosis(TLK) were 10.3±9.9º and 15.6±10.4º, respectively. Operative corrected degree(OCD) of FLK and TLK were 6.8±7.9º and 7.7±8.4º, respectively. Preoperative parameters, including FLK, TLK, Pelvic tilt (PT), Sacral slope (SS), Lumbar lordosis (LL), were no different in the different fracture sites. PT-OCD is greater in L2 L5 fractures than in T12 L1(t=0.82, P=0.03). FLK-OCD(B=0.36), LL-OCD(B=-0.34) and PT-OCD(B=0.22), as well as age(B=-0.23) were independent factors to influence TLK-OCD. Pelvis anteversion and high FLK-OCD was associated with a more satisfactory correction of the TLK deformity. TLK-OCD was negatively influenced by age.

Conclusions: Short segment fixation surgery can correct TLK caused by fractures. Satisfactory TLK-OCD is related to excellent fracture reduction, pelvic anteversion, and younger patients. With FLK fixed by operation, the pelvis rotates from rear to front, more obviously in lumbar fractures.

Trial registration: The trial was registered in the Iranian Registry of Clinical Trials (www.irct.ir) on 03/02/2019 as IRCT20180408039227N1.

Background

Pelvic tilt(PT) represents the sagittal rotation of the pelvis. The importance of the pelvis in maintaining the sagittal balance of the spine has become increasingly recognized[1]. So, it is impotent to assess the pelvic rotation in patients with thoracolumbar fractures.

Thoracolumbar kyphosis induced by spinal fractures can alter the overall sagittal alignment[2]. It is essential to restore spinal alignment in patients with thoracolumbar burst fractures[3]. Thanks to pedicle screws purchasing all three spinal columns, the short segment fixation (SSF) could correct the segmental kyphotic deformity and preserve as many motion segments as possible[4]. A study showed that short segment instrumentation could correct kyphosis angles ranging from 6.2º to 21.4º[5].

However, the impact of SSF on spinopelvic parameters in patients with spinal burst fracture remain uncleared. This study aims to: 1) Explore the effects of SSF on spinopelvic sagittal alignment. 2) Screen spinopelvic parameters influenced by spinal burst fractures. 3) Study the relationship between the pelvic rotation and thoracolumbar kyphosis. 4) Discuss the influence of fracture level on spinopelvic sagittal alignment.

Methods

1 General Data

Patients with thoracolumbar fractures treated with short-segment fixation surgery from February 2018 to January 2021 were retrospectively evaluated, The inclusion criteria included: 1) one-level burst fracture. 2) a posterior SSF surgery with pedicle screw including three levels. 3) no other combined severe injury. The exclusion criteria included: 1)patients with significant osteoporosis, ankylosing spondylitis, or other diseases which may affect the vertebral structure, 2) patients with incomplete clinical records, 3) Patients with a history of prior spine surgery. This study has been approved by the Ethics Committee of the Second Central Hospital of Baoding.

2 Imaging Measurement Method

Spinopelvic parameters were measured on lateral digital spinal radiographs utilizing Surgimap Spine Software New York, USA). All measurements were made twice by two observers. Data included in this study was average with two sets of measurement data.

Standard measurement techniques of spinopelvic parameters(Fig1, Fig2):

Pelvic incidence(PI) was defined as the angle between the line perpendicular to the middle of the sacral endplate and the line extending from the sacral endplate to the geometric center of the femoral head.

Pelvic tilt (PT) was defined as the angle between the vertical line and the line joining the middle of the sacral plate and the center of the bicoxofemoral axis.

Sacral slope (SS) was defined as the angle between the horizontal line and the cranial sacral endplate tangent.

Fractured level kyphosis(FLK) was defined as the angle between the superior endplate of the upper and the inferior endplate of the lower adjacent vertebra of the injured vertebrae.

Thoracolumbar kyphosis(TLK) was defined as the angle between the superior endplate of T10 and the inferior endplate of L2.

Lumbar lordosis (LL) was defined as the angle between the cranial endplate of L1 and the endplate of S1.

The sagittal vertical axis(SVA) was defined as the deviation of the C7 plumb line from the superior posterior endplate of S1. SVA exceeding 50 mm was defined as sagittal decompensation.

The fracture site was divided into Thoracolumbar Fracture(T12 L1) and Lumbar Fracture(L2 L5)

3 Statistical Method

The parameters were analyzed by SPSS software (IBM SPSS Statistics 25). Preoperative spinopelvic parameters and OCD in different Fracture sites were determined and compared with the Independent Samples t-Test. Multifactor Regression Analysis was used to investigate the influencing factors of TLK. The statistical difference level was 0.05.

Results

1 spinopelvic parameter determined

A total of 41 patients with Thoracolumbar fractures treated with short-segment fixation surgery were identified (27 males and 14 females). The patients had a mean age of 47.1 ± 9.9(30 66) years. Sagittal decompensation was not found in all of the patients included in the study.

The mean PI was 44.1 ± 4.7º(range, 33.0 56.1º). The values of the spinopelvic parameters are reported in Table 1. For the magnitudes of preoperative PT, SS, FLK, TLK, and LL, there were no statistically significant differences in fracture sites (Table 2). OCD of PT is greater in L2 L5 fractures than in T12 L1 (Table 3).

2 The Influencing Factors of TLK-OCD

The magnitude of FLK-OCD, PT-OCD, and age were independent factors to influence TLK-OCD. High OCD of FLK and pelvis anteversion was associated with a more satisfactory correction of the TLK deformity. OCD of TLK was negatively impacted by age (Table 4).

Table 1
Mean Value of Perioperative Spinopelvic Parameters (Mean ± SD)

	Preop (Degree)	**OCD (Degree)**
PT	12.1 ± 5.3	− .7 ± 7.1
SS	33.4 ± 6.9	.8 ± 8.0
FLK	10.2 ± 9.9	6.8 ± 7.9
TLK	15.6 ± 10.4	7.7 ± 8.4
LL	8.2 ± 10.5	.1 ± 9.9

Table 2
Preoperative PT, SS, FLK, TLK, LL in Different Fracture Site

	T12▯L1(N = 24)	**L2▯L5(N = 17)**	**t**	**P**
PT	13.0 ± 5.3	10.8 ± 5.3	1.33	.81
FLK	15.1 ± 7.4	3.4 ± 9.0	4.53	.48
TLK	16.8 ± 7.9	13.8 ± 13.3	.91	.05
LL	40.1 ± 11.1	35.5 ± 9.3	1.38	.69

Table 3
OCD of Spinopelvic Parameters in Different Fracture Sites

	T1▯L1(N = 24)	**L2▯L5(N = 17)**	**t**	**P**
PT-OCD	0 ± 6.1	-1.8 ± 8.4	.82	.03*
FLK-OCD	10.0 ± 6.3	2.4 ± 8.0	3.40	.85
TLK-OCD	9.9 ± 7.6	4.7 ± 8.8	2.01	.30
LL-OCD	2.5 ± 10.2	-3.2 ± 8.7	1.89	.72

*: PT-OCD is greater in L2 L5 fractures compared with T12 L1. TLK-OCD: Thoracolumbar kyphosis-Operative corrected degree; FLK-OCD: Fractured level kyphosis-Operative corrected degree; LL-OCD: Lumbar lordosis-Operative corrected degree; PT-OCD: Pelvic tilt-Operative corrected degree.

Table 4
The Influencing Factors of TLK-OCD

Factors	Beta	t	P
FLK-OCD	.36	3.22	.00
PT-OCD	.22	2.34	.02
age	− .23	-2.44	.02

TLK-OCD: Thoracolumbar kyphosis-Operative corrected degree; FLK-OCD: Fractured level kyphosis-Operative corrected degree; PT-OCD: Pelvic tilt-Operative corrected degree.

Discussion

Surgical management of thoracolumbar burst fractures is to correct kyphosis and provide adequate biomechanical stability for early mobilization while reducing surgical invasiveness and associated complications[6]. Biomechanically, having two or more fixation levels above and below the fracture is a better option for thoracolumbar burst fractures, providing greater mechanical stiffness and reducing the likelihood of segment collapse and implant failure[7]. However, in addition to the interruption of spinal motion segments, long-stage immobilization was associated with more severe surgical invasiveness[8]. SSF is sufficient in thoracolumbar burst fractures and has demonstrated promising results[9]. This study found that preoperative FLK was 10.3 ± 9.9º and FLK-OCD was 6.8 ± 7.9º. Correspondingly, preoperative TLK was 15.6 ± 10.4º, and TLK-OCD was 7.7 ± 8.4º.

Considering that original magnitude can influence spinopelvic parameters, OCD was a better index to reflect the influence of SSF on spinopelvic sagittal alignment. Although the current study found that spinopelvic parameters (FLK, TLK, PT, SS, LL) were no different in different fracture sites. We found that when the fracture was located at the lumbar spine, the PT-OCD was significantly greater than when the fracture was located at the thoracolumbar junction. The phenomenon indicated that the pelvis was anteverted when the fracture was present at the lumbar spine to maintain sagittal spinal balance after surgery. Kyphosis in the lumbar levels will have a more significant impact on the pelvic rotation.

TLK should disturb the overall spinopelvic balance[10]. When FLK was corrected by surgery, the magnitude of TLK became smaller accordingly. The current study shows that PT-OCD is positively associated with TLK-OCD(B = 0.22). For adulthood, the PI will remain unchanged[11]. PT improved the pelvis rotates from front to rear to adapt to the increased kyphosis in the fracture site[12]. Along with the TLK reduced by surgery, the pelvis rotates from rear to front to return to the normal position.

Spinal biomechanical functions appear to be affected by aging because of decreased spinal mobility[13]. Age-based spinal flexibility can help predict postoperative alignment[14]. Current studies found that age(B=-0.23) can negatively impact TLK-OCD. The older, the easier it is to have residual thoracolumbar kyphosis.

The current study has several limitations. Its retrospective nature and small sample reduced the level of evidence and limited its statistical power. Another limitation of this study was the lack of spinopelvic parameters value in asymptomatic Chinese adults for normal control.

Conclusions

TLK caused by fractures can be corrected by SSF surgery. Satisfactory OCD of TLK is related to excellent fracture reduction, pelvis anteversion, and lumbar hyperlordosis. The younger the patient and the lower PI, the more significant the impact on the OCD of TLK.

Declarations

Ethics approval and consent to participate

The study was conducted concerning the Helsinki Declaration; all the participants (parents) signed informed consent to allow the use of clinical data for research purposes. This study has been approved by the Ethics Committee of Second Central Hospital of Baoding.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

Kepeng Li conceived and designed the study. Ye Han and Jin-zeng Zuo analyzed the data. Guoju Ma and Heyi Zhao wrote the manuscript. All authors read and approved the final manuscript.

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Figures

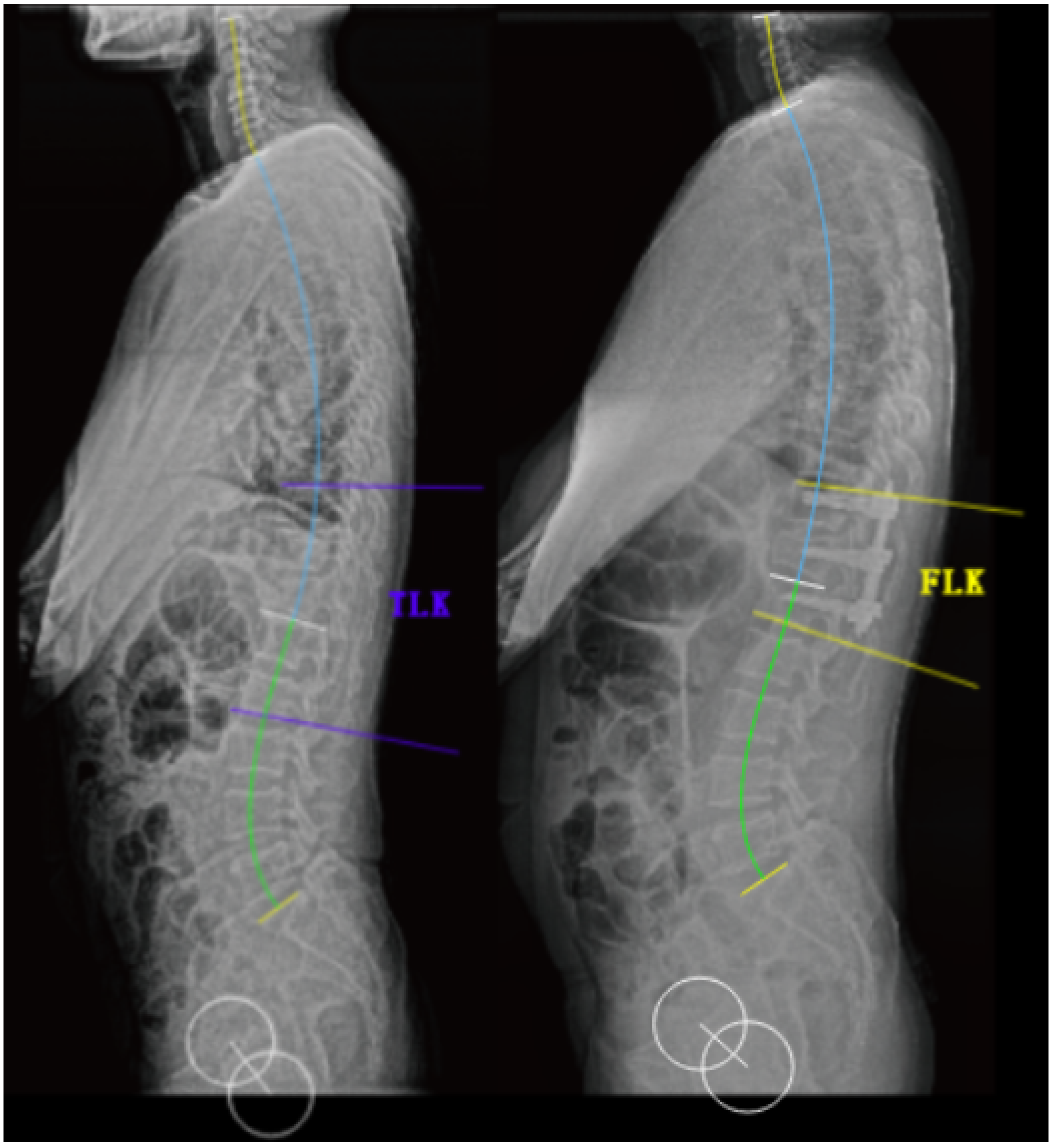

Figure 1

Thoracolumbar kyphosis before surgery (left) has been corrected after surgery (right). **FLK(Fractured level kyphosis)**: the angle between the superior endplate of the upper and the inferior endplate of the lower adjacent vertebra of the injured vertebrae; **TLK(Thoracolumbar kyphosis)**: the angle between the superior endplate of T10 and the inferior endplate of L2.

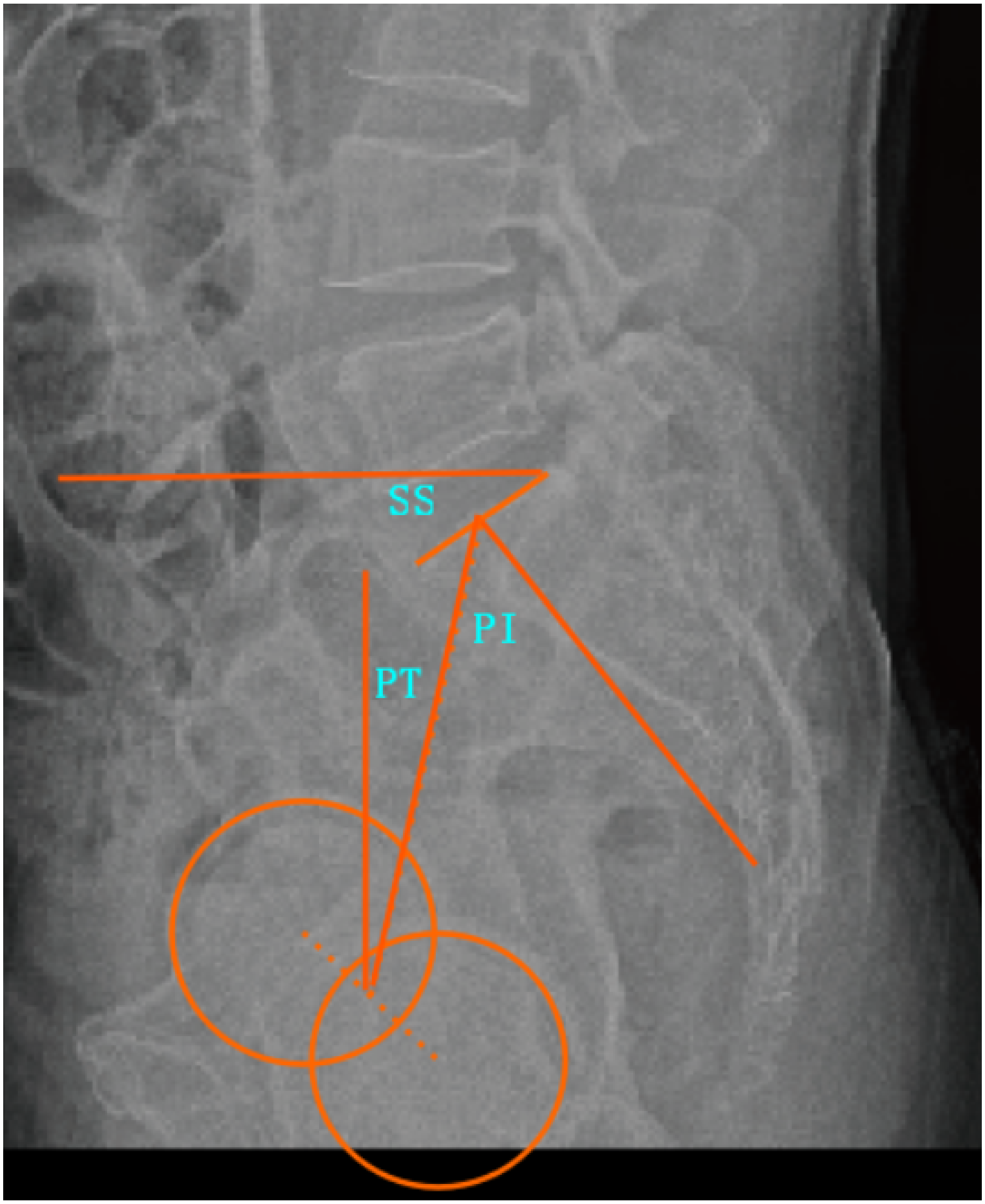

Figure 2

PI(Pelvic incidence): the angle between the line perpendicular to the middle of the sacral endplate and the line extending from the midpoint of the sacral endplate to the geometric center of the femoral head; **PT (Pelvic tilt)**: the angle between the vertical line and the line joining the middle of the sacral plate and the center of the bicoxofemoral axis; **SS (Sacral slope)**: the angle between the horizontal line and the cranial sacral endplate tangent.