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ORIGINAL STUDY

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Long-versus short-segment fixation with an index vertebral screw for management of thoracolumbar fractures

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The choice of the best stabilization technique for thoracolumbar fractures remains controversial. While LSF includes too many motion segments, SSF is associated with a high rate of fixation failure and subsequent loss of kyphotic correction. Our objective is to compare the surgical, clinical, and radiological outcomes of thoracolumbar spine fixation using long-segment fixation (LSF) versus short-segment fixation (SSF) with a screw in the fractured vertebra. We retrospectively evaluated 63 patients with single-level thoracolumbar fracture types A and B treated during the period between 2010 and 2017 in our institution. Group A (30 patients) was treated by SSF with an intermediate screw in the fractured vertebra, while group B (33 patients) was treated by LSF. Both groups were compared in terms of surgical, clinical, and radiological outcomes. The mean operative blood loss was significantly lower in group A than in group B (451.3 ± 79.9 and 690 ± 92.1 ml, respectively). The mean operative time in Group A was significantly shorter than in group B (58.4 ± 14.8 and 81.5 ± 12.3 minutes, respectively). Both groups achieved a similar Visual Analogue Scale (VAS) for pain and Oswestry Disability Index (ODI) score. No significant difference was found as regards the kyphotic angle correction and the correction loss at final follow-up. In conclusion, SSF with a screw in the fractured vertebra achieved comparable functional and radiological outcomes to LSS with less blood loss and operative time.

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INTRODUCTION

Thoracolumbar fractures are common spinal injuries associated with high energy trauma such as motor vehicle accidents and falling from heights *(1)*. The aim of treating these fractures is to restore spinal alignment and stability, decompress the spinal canal, achieve non-eventful healing with early mobilization, relieve pain, and avoid progressive kyphosis *(2)*. Different surgical modalities have been described to achieve these goals, including posterior short-segment or long-segment pedicle

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screw fixation, direct anterior decompression through corpectomy, and combined anterior and posterior spinal approaches *(2-4)*. However, the best surgical technique remains unclear *(5)*.

Although long-segment fixation (LSF) has been successfully used for the treatment of thoracolumbar fractures *(6)*, concerns were raised due to the inclusion of too many motion segments. Consequently, it was replaced gradually by short-segment fixation (SSF) *(2,3,7-9)*. Unfortunately, SSF was associated with a higher rate of fixation failure, and subsequent loss of correction *(10,12)*. Inclusion of the fracture level has recently been introduced to provide better kyphotic correction and minimize complication rates *(8,13,14)*.

Limited number of studies in the literature compared LSF versus SSF with inclusion of the fracture level *(15-17)*. Therefore, we conducted this retrospective study to compare the surgical, clinical, and radiological outcomes of thoracolumbar spine fixation using LSF versus SSF with an intermediate vertebral screw.

MATERIALS AND METHODS

We retrieved prospectively collected data of 63 patients operated for thoracolumbar fractures in our institution between the years 2010 and 2017 for retrospective analysis. All cases aged between 18 and 60 years old, with single-level traumatic fractures of the thoracolumbar junction (T11-L2) types A and B according to AOSpine thoracolumbar spine injury classification system *(18,19)*. We excluded patients who had multiple level fractures, fractures not involving T11-L2 vertebrae, AO thoracolumbar fractures type C, pathological fractures, incomplete clinical or radiological data, and revision cases. Due to the retrospective nature of this study, approval of our Institutional Review Board was neither sought nor needed. Informed consent was obtained from all patients included in the study.

The patients were divided into two groups according to the number of instrumented levels. Group A included patients treated by SSF, i.e., fixation of one level above and below the fractured vertebra, with a screw in the fractured vertebra, provided that at least one of the two pedicles of the fractured vertebra was intact (Figure 1). Group B included patients treated with LSF, i.e., fixation of two levels above and below the fractured vertebra (Figure 2). The procedures were carried out by two different surgeons. The decision between SSF and LSF was based on the integrity of the pedicles of the fractured vertebrae. LSF was performed if both pedicles of the intermediate vertebra were fractured. On the other hand, SSF with intermediate

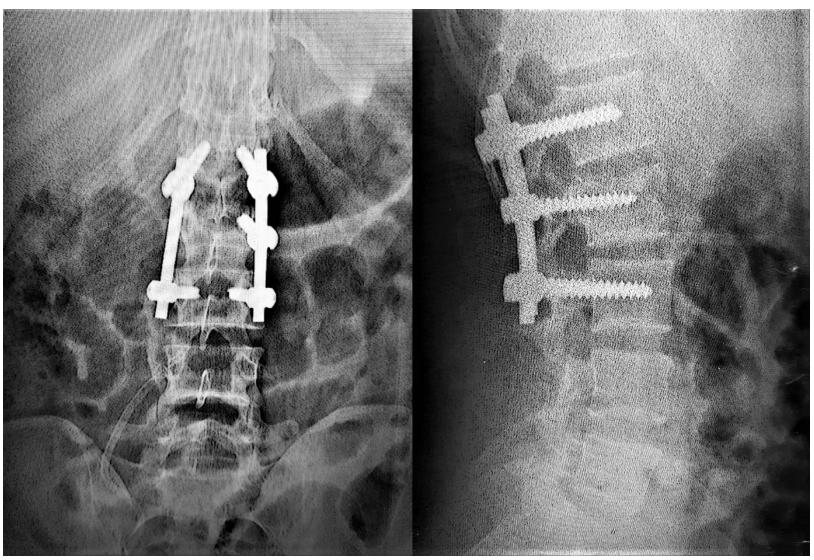

Fig. 1. – Anteroposterior and lateral radiographs of a patient with L2 vertebra fracture who received SSF with the inclusion of the fractured vertebra.

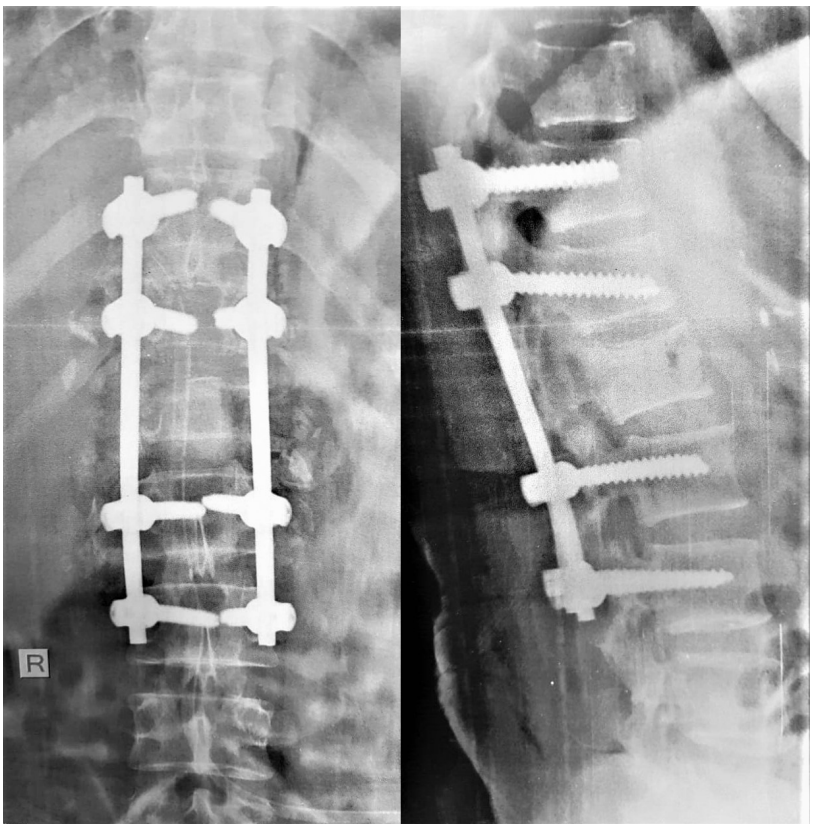

Fig. 2. – Anteroposterior and lateral radiographs of a patient with L1 vertebra fracture who received LSF.

screw was performed if at least one pedicle was intact.

After emphasizing patients' hemodynamic stabilization, neurological status was documented using the American Spinal Injury Association (ASIA) impairment scale *(20)*. All patients underwent radiological evaluation using x-rays and computed tomography (CT) for fracture pattern detection, and assessment of the pedicle integrity for screw fixation.

Following general anesthesia, each patient was positioned prone on the Jackson table. Postural reduction of the kyphosis was achieved by the patient's hyperextension position on the spinal frame using ligamentotaxis. The reduction was checked intraoperatively using fluoroscopic guidance. A standard posterior midline approach was performed to expose the laminae, and facet joints of either one or two levels above and below according to the intended segments to be fixed, and pedicular screws were inserted accordingly. Then, the position of the pedicular screws was checked radiologically. Indirect reduction using ligamentotaxis was carried out provided that the surgery was not delayed, and the canal is not severely compromised. Ligamentotaxis relied on the intact but buckled posterior longitudinal ligament (PLL) to guide repositioning of the retropulsed fracture fragments by the application of distraction forces. Controlled compression was performed in type B fractures. Posterior decompression was performed through a laminectomy in cases presented with neurological deficits. The retropulsed fragment was impacted into the vertebral body. Fusion was not performed in any case provided that the implants would be removed after at least one year to avoid implant failure. Postoperative mobilization was allowed for all patients when tolerated. A rigid lumbosacral brace was applied for 6 weeks.

The amount of intraoperative blood loss and operation time was recorded for both groups for

comparison. The neurological status was assessed using the AISA impairment scale preoperatively and at final follow-up *(20)*. Functional outcomes were assessed using Visual Analogue Scale (VAS) for pain and a valid Arabic version of the Oswestry Disability Index (ODI) questionnaire at final follow-up *(21)*. Radiological evaluation of kyphosis was performed using the Cobb angle method (Figure 3) *(22,23)*. Three authors measured the kyphotic angle preoperatively, postoperatively and at final follow-up, and a mean value was considered for analysis. Loss of angle correction between postoperative and final follow-up values was measured as well.

Quantitative variables were expressed as means and standard deviation, while qualitative variables were expressed as frequencies and percentages using SPSS Version 25.0 (IBM Corp, Armonk, NY). Preoperative and postoperative results were compared using the paired sample t-test. Comparison of the two groups was carried out using the independent sample t-test. The level of significance was set at $P \leq 0.05$.

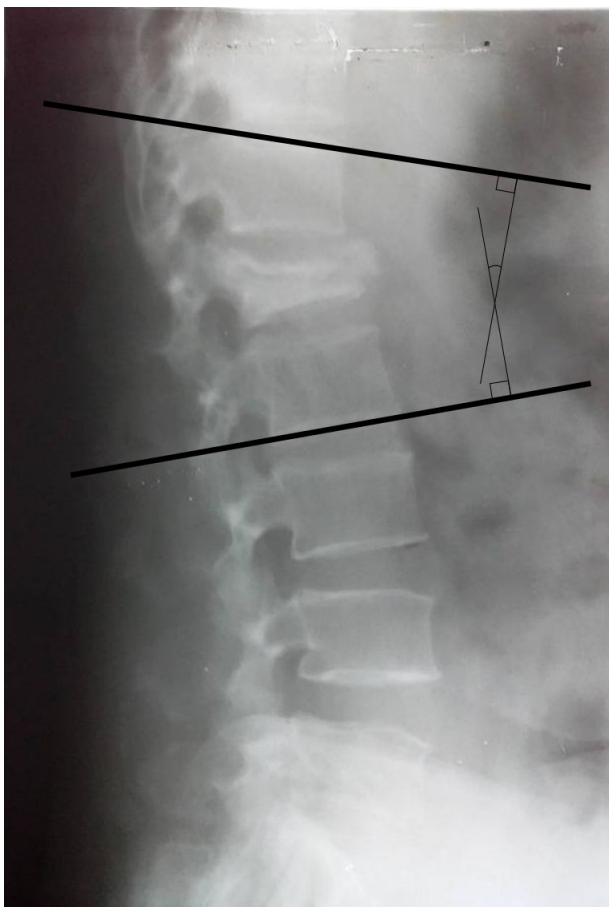

Fig. 3. – Measurement of kyphotic angle in the lateral radiographs using the Cobb angle method.

RESULTS

A total of 63 patients (30 patients in group A and 33 patients in group B) were included in the study. Characteristics of included patients are demonstrated in Table I. No differences were found between the two groups preoperatively in terms of age, gender, fracture type, fracture level, and neurological status (P value > 0.05). The mean follow-up duration was 24.3 ± 6.3 months (range, 15 – 36 months), with no difference in follow-up duration between group A (25 ± 6 months), and group B (23.7 ± 6.5 months).

The mean amount of blood loss was 451.3 ± 79.9 ml in group A, and 690 ± 92.1 ml in group B. The mean operative time was 58.4 ± 14.8 and 84.6 ± 15.3 minutes in groups A and B, respectively. A statistically significant difference in favor of group A was found (P < 0.05).

At final follow-up, the mean VAS for pain in group A was 2.27 ± 0.98, and the mean VAS for group B was 2.5 ± 1.13 with no significant difference between the two surgical procedures (P = 0.432). The final follow-up DOI was 11 ± 2.4 in group A, and 13 ± 3.4 in group B with no significant difference between the two groups neither (P = 0.138).

The cobb angle in group A improved from a mean of 21.9º ± 5º preoperatively to 4.2º ± 1.5º postoperatively (P = 0.000) with insignificant loss of correction at the final follow up 4.1º ± 1.4º (P = 0.875). Similar results were achieved in group B where the kyphotic angle improved from 20.7º ± 3.7º preoperatively to 3.9º ± 1.5º postoperatively (P = 0.000) with insignificant loss of correction at the final follow up 4.0º ± 1.6º (P = 0.912). No statistically significant difference between the two groups was detected at preoperative, postoperative, or final follow-up periods (P > 0.05).

Six patients had neurological deficits preoperatively. Four improved form AISA D to ASIA E, while the remaining two showed no neurological improvement (remained ASIA C). No

Table I. – Comparison of patients' demographic data (N = 63)

Parameter	Group A (N = 30)	Group B (N = 33)
Age*, years	35.25 ± 9.49	33.81 ± 10.53
Gender**		
Male	18 (60)	17 (51.5)
Female	12 (40)	16 (48.5)
Fracture type**		
A3	15 (50)	14 (42.4)
A4	8 (26.7)	9 (27.3)
B1	4 (13.3)	5 (15.2)
B2	3 (10)	5 (15.2)
Fracture level**		
D11	3 (10)	8 (24.2)
D12	8 (26.7)	9 (27.3)
L1	12 (40)	10 (30.3)
L2	7 (23.3)	6 (18.2)
Neurological deficit**		
ASIA C	1 (3.3)	1 (3)
ASIA D	2 (6.7)	3 (9.1)
Follow up*, months	25 ± 6	23.7 ± 6.5

*Data are presented as mean ± SD; **Data are presented as No. (%); ASIA: American Spinal Injury Association

statistically significant difference between the two groups was found (P = 0.364).

Three patients developed superficial infection, one in group A, and two in group B. All cases with infection were treated conservatively. Another patient from group A had CSF leakage that was managed conservatively as well. No patients in either group had implant failure or screw breakage during follow-up. Figures 4 and 5 show examples of two female patients who underwent SSF with intermediate screw and LSF, respectively. Instrumentation was removed in both patients to avoid implant-related complications.

Surgical, clinical, and radiological results are summarized in Table II.

DISCUSSION

The thoracolumbar junctional region (T11-L2) is the most commonly fractured segment (60-70%) of the vertebral column *(24,25)*. Posterior spinal instrumentation has been the most frequently used approach owing to its lower morbidity and mortality rates compared to anterior approach *(26)*. However, the length of posterior segment fixation remains controversial *(27)*.

LSF used to be the mainstay in treating thoracolumbar fractures. It provides rigid fixation at multiple points to distribute the stress, while achieving and maintaining spine alignment. Nevertheless, LSF is associated with loss of motion segments. On the other hand, SSF has the advantage of less involvement of motion segments compared to longer instrumentation. However, it has been criticized because of the high risk of implant failure and progression of kyphosis *(28)*. In a cadaveric biomechanical study, Mahar A et al. studied the inclusion of the fracture level in the construct *(8)*. They concluded that insertion of a pedicle screw at the fractured vertebra enhanced the hardware stiffness during axial torsion and protected the fractured vertebral body against anterior loading forces. Furthermore, Guven O et al. found that incorporation of the fracture level allowed for better intraoperative

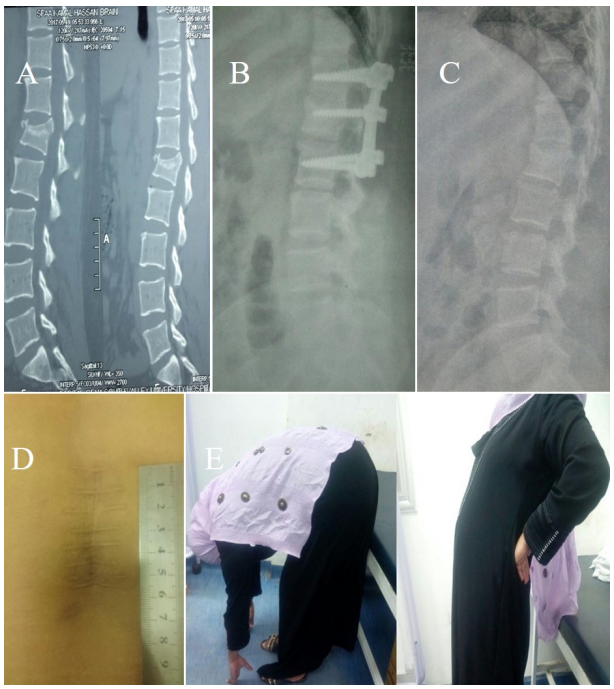

Fig. 4. – Female patient, 30 years old with fracture of L1 AO type A3. She was neurologically intact and treated by short segment fixation from D12 to L2 with a screw in the fractured vertebra with satisfactory clinical outcome. (A) Preoperative CT scan. (B) Postoperative plain X-ray. (C) Plain X-ray after metal removal. (D) Length of surgical wound. (E) Spinal motion after metal removal.

kyphotic correction and perpetuation of the correction postoperatively *(14)*. Similarly, in a randomized study by Farrokhi et al, 80 patients were randomly assigned to one of two groups of SSF *(13)*. One group received an index level screw, and the other group did not. They found that the additional screw resulted in better kyphosis correction, fewer metal failures, and comparable or even better outcomes. In a recent study by Chokshi et al, 50 patients with thoracolumbar fracture dislocation were treated by SSF and an index vertebral screw *(29)*. They concluded that SSF with an index level screw achieved satisfactory outcomes as well in terms of angle correction and maintenance in patients with thoracolumbar fracture-dislocation and McCormack load sharing score 6. In contrast, Eno et al. found that short same segment fixation was not able to maintain kyphotic correction at long-term follow-up. However, pain and disability improved significantly *(28)*.

In our study, we compared the surgical, clinical, and radiological outcomes of thoracolumbar spine fractures treated by either LSF or SSF with a screw inserted in the index level vertebra. Overall, both techniques have comparable results, but SSF had

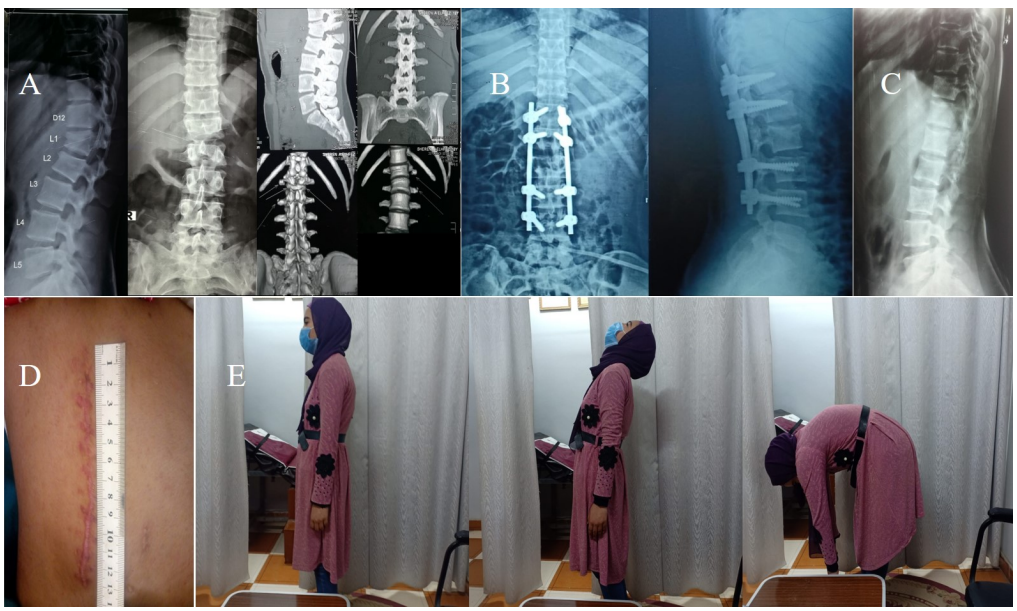

Fig. 5. – Female patient, 16 years old with fracture of L1 AO type B1. She was neurologically intact and treated by long segment fixation from D11 to L3 with satisfactory clinical outcome. (A) Preoperative X-ray and CT scan. (B) Postoperative plain X-rays. (C) Plain X-ray after metal removal. (D) Length of surgical wound. (E) Spinal motion after metal removal

Table II. – Comparison of surgical, clinical, and radiological results (N = 63)

Parameter	Group A (N = 30)	Group B (N = 33)	P value*
Blood loss, ml	451.3 ± 79.9	690 ± 92.1	0.000
Operative time, min	58.4 ± 14.8	84.6 ± 15.3	0.000
VAS for pain	2.27 ± 0.98	2.5 ± 1.13	0.432
ODI	11 ± 2.4	13 ± 3.4	0.138
Angle of correction			
Preoperative	21.9 ± 5	20.7 ± 3.7	0.186
Postoperative	4.2 ± 1.5	3.9 ± 1.5	0.085
P value**	0.000	0.000	
Final follow-up	4.1 ± 1.4	4.0 ± 1.6	0.883
P value**	0.875	0.912	

Data are presented as mean ± SD; * Independent sample t-test; ** Paired sample t-test; VAS: Visual Analogue Scale; ODI: Oswestry Disability Index.

the advantage of less operative time and blood loss compared to LSF.

In our series, SSF group had a mean kyphotic angle of 21.9º preoperatively, 4.2º postoperatively, and 4.1º at final follow-up, while LSF group had a mean kyphotic angle of 20.7º preoperatively, 3.9º postoperatively, and 4.0º at final follow-up. Both groups achieved significant kyphotic angle correction, with no statistically significant difference. Both techniques were able to preserve the correction angle throughout the follow-up period with insignificant difference in correction loss between the two groups. Similar results were obtained by previous studies. Sallam et al. *(16)* and Mittal et al. *(17)* found no superiority of the LSF over SSF with index level fixation in terms of kyphotic angle correction and maintenance. Dobran et al. *(15)* showed that inclusion of the fractured vertebra in the SSF group resulted in an average correction of local kyphosis angle of 6.73º, whereas the LSF achieved an average correction of 5.46º (P = 0.243). They found that correction loss in LSF group (0.63°) was slightly less than in SSF group (1.74°) with no statistical relevance (P = 0.427).

Previous studies compared between LSF and SSF with an index vertebral screw as regards clinical outcomes. In a single-center retrospective study by Mittal et al. *(17)*, the mean VAS score was 2.17 and 2.08 for LSF and SSF, respectively, and average ODI score in LSF and SSF groups at final follow up were 65.5 and 54.4, respectively. Comparably, functional parameters were similar between the two groups included in our study. At the final follow-up, the mean VAS for pain was 2.27 ± 0.98 and 2.5 ± 1.13 in SSF and LSF groups, respectively. The mean ODI score was 11 ± 2.4 in the SSF group, and 13 ± 3.4 in the LSF group. No significant difference was found in terms of VAS or ODI (P = 0.432 and 0.138, respectively).

In our study, SSF group had a mean blood loss of 451.3 ± 79.9 ml, while the LSF group had a mean blood loss of 690 ± 92.1 (P = 0.000). The operation time was significantly lower in the SSF group with a mean of 58.4 ± 14.8 min compared to 84.6 ± 15.3 min in the LSF group (P = 0.000). Similarly, previous authors found that SSF has the advantage of better surgical outcomes in terms of amount of blood loss and operative time *(17,30)*. Chen et al. *(30)* compared LSF with SSF and anterior fusion. They recorded a total amount of blood loss of 730.6 ml and 2001.4 ml in SSF and LSF groups, respectively. SSF group had less operative time compared to LSF group as well (240.0 and 457.1 min, respectively).

The study has some limitations, including the retrospective design, and the relatively small sample size. Therefore, future randomized controlled trials with larger sample sizes are necessary to establish more solid evidence on the optimal length of posterior spinal instrumentation and highlight the value of inclusion of the fractured vertebra.

CONCLUSION

SSF with a screw in the fractured vertebra is considered a reliable treatment option, hence it achieves comparable clinical and radiological outcomes to LSF with less involvement of motion segments, less operative time, and blood loss. Therefore, we recommend the inclusion of the fractured vertebra when adopting SSF in types A and B thoracolumbar fractures.

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