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Could Intermediate Screw in Thoracolumbar Fracture Fixation Save Motion Levels? Comparative Study between Long-Segment and Short-Segment with Intermediate Screw Fixation

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ABSTRACT

Background Data: Thoracolumbar fractures are commonly managed by posterior pedicle screw fixation. Controversy about the number of levels involved in the fixation remains as the stability of the short-segment fixation remains questionable. Recently, it has been shown that application of intermediate screw in the fractured vertebra improves the biomechanical stability of the short-segment construct.

Purpose: To compare the outcome of long-segment fixation (LSF) versus short-segment fixation with intermediate screws (SSFIS) in the management of the thoracolumbar burst fractures.

Study Design: A prospective, nonrandomized clinical controlled trial.

Patients and Methods: Fifty patients with thoracolumbar burst fracture (T11-L2) types A3 and A4 AOSpine classification with a Thoracolumbar Injury Classification and Severity (TLICS) scale of more than 4 were treated between 2009 and 2014 with posterior pedicle screw fixation. Patients were divided into two groups according to the number of instrumented levels. Group 1 included 25 patients treated with LSF (two levels above and two levels below the fractured level) while Group 2 included 25 patients treated by SSFIS (one level above and one level below with 2 intermediate screws in the fractured level). The patients were evaluated for local kyphotic angle (LKA) correction and maintenance, anterior vertebral body height (AVH) compression, and Visual Analogue Scale (VAS) for back pain and treatment related complications. Construct failure was defined as screw pullout or instrument breakage.

Results: The two groups were similar with regard to age, sex, fractured levels, fracture type, TLICS score, preoperative local kyphotic angle, and anterior vertebral body height compression. Postoperative correction of the local vertebral compression assessed with LKA and AVH significantly improved in both groups compared to the preoperative degree. There was no significant difference in the two groups in early postoperative or follow-up regarding the degree of correction and its maintenance. No construct failure or major treatment related complication was encountered in both groups with significant reduction of VAS and ODI in both groups between early postoperative and late follow-up (13.5±2 months).

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Conclusion: Intermediate screw applied in the fractured level in management of thoracolumbar burst fracture improves the correction and maintenance of local kyphosis in short-segment fixation like long-segment construct with saving vertebral motion levels from being fixed. More randomized controlled and multicenter studies are needed to support these findings. (2019ESJ175)

Keywords: Thoracolumbar fracture, long-segment fixation, short-segment fixation, intermediate screws, burst fracture.

INTRODUCTION

Thoracolumbar fractures are considered to be the most common fracture in the spinal column. This area is more vulnerable to failure in trauma, as it is the junction between the rigid thoracic spine due to its attachment to the rib cage and the sternum and the more mobile lumbar spine.[20]

Posterior pedicle screw fixation had gained popularity in the management of these fractures. The biomechanical stability of the different pedicle screws constructs had been studied thoroughly and long-segment fixation, with two levels fixed above and below the fractured level, had shown stiffer construct and more stability in comparison to short-segment fixation (one level above and below the fractured level).[10]

Theoretically, decreasing the number of fixed levels will lead to better patient surgical outcome considering postoperative pain and function and adding pedicle screw in the fractured level had shown increased stability of the short-segment constructs in several biomechanical studies.[2,12] Also, the load-sharing classification had been described as a straight forward way to describe the anterior body comminution and had been proven to correlate with the degree of collapse after surgical treatment.[13] In fact, some studies[16,19] compared the long-segment construct with the short-segment but very few used the intermediate screw in the short-segment cases.[3]

The aim of our study is to compare the outcome of long-segment fixation (LSF) versus short-segment fixation with intermediate screws (SSFIS) in the management of the thoracolumbar burst fractures.

PATIENTS AND METHODS

A comparative clinical study was conducted on 50 patients with thoracolumbar burst fracture (T11-L2) types A3 and A4 AOSpine classification, who were treated between 2009 and 2014 with posterior pedicle screw fixation. The patients were admitted to the emergency department at Zagazig University hospitals. Informed consent was taken from all patients.

They were included in our study if the patients were less than 60 years old and the fracture was classified as A3 or A4 according to the AOSpine classification[17] with a Thoracolumbar Injury Classification and Severity (TLICS) scale[8] of more than 4 and a load-sharing classification score[13] of less than 6 and there was no history of osteoporosis or other major medical diseases. All patients were subjected to clinical examination and radiological evaluation (X-ray and CT scan were done). The patients were evaluated for local kyphotic angle (LKA) and anterior vertebral body height (AVH) compression. All patients were neurologically intact.

Surgical Procedures:

All the patients were operated upon within the first 48 hours after stabilization of the general condition of the patients. The patients were operated upon under general anesthesia with administration of 2gm 3rd generation cephalosporin antibiotics intravenously. The patients were placed in prone position on a four-post frame which help in position reduction of the fractured level and the reduction was assessed using intraoperative fluoroscopy. Standard posterior approach was used to expose desired levels to be included in the fixation construct with the guidance of the intraoperative images. The patients, then, were

divided into two groups according to the number of instrumented levels.

Long-segment fixation (LSF) group was where we used long-segment construct, fixing two levels above and below the fractured vertebra, without inclusion of the fractured vertebra, by pedicle screws (Figure 1). The rods were contoured with hypokyphosis in the proximal levels and more lordosis in the distal one; this is to increase the corrective forces at the fracture to help in reducing local kyphosis of the fractured level.

Short-segment fixation with intermediate screw (SSFIS) group was treated by a short-segment construct (one level above and below the fractured level) with the application of two pedicle screws in the fractured vertebra. The intermediate screws were applied as the first step in this technique and usually they were fixed uniplanar screws. The rods were usually slightly lordotic to overcome the kyphotic deformity of the fracture (Figure 2).

The final position of the screws and the reduction were checked by the fluoroscopy at the end of the procedures and the wounds were closed with the use of suction drains in layers

Postoperative Care:

All patients were neurologically tested before leaving the operating room. The patients were kept in bed till the wound drains were removed in the first two days and then they were encouraged to walk or begin physiotherapy on the third day according to the preoperative neurological status. First postoperative X-ray was done after 24 hours from the surgery. The patients were discharged from the hospital on the 4th postoperative day.

Follow-up:

Follow-up visits were scheduled at 3 and 6 months and at final visit, where the patients were evaluated by X-ray for local kyphotic angle (LKA) and anterior vertebral body height (AVH) compression correction and maintenance.[6] The Visual Analogue Scale (VAS) was used to evaluate the back pain, and functional outcome was evaluated by the changes in the Oswestry Disability Index (ODI). Also, treatment related complications were reported. Construct failure was defined as screw pullout or instrument breakage.

Statistical Analysis:

All data were collected, tabulated, and statistically analyzed using SPSS 23.0 for Windows (SPSS Inc., Chicago, IL, USA). Continuous quantitative data were checked for normality by using Shapiro-Wilk test. Quantitative variables were expressed as mean ±SD. Independent samples Student's *t*-test was used to compare between two groups of independent normally distributed data. Paired *t*-test was used to compare two groups of dependent data. Percent of categorical variables was compared using Pearson's Chi-Square (χ^2) test. All tests were two sided with $P<0.05$ being considered statistically significant.

RESULTS

A total of 50 patients who met the inclusion criteria of this study and 25 patients were nonrandomly allocated in each group. There were no significant differences in patients' demographic data or characteristics between the two groups (Table 1) with the most common fractured levels being T12 and L1 levels.

Analysis of the data showed that there was a significant correction of the local kyphotic angle within each group, but there was no significant difference between both groups. In the LSF group, the mean LKA significantly corrected from 14.20±2.06° (range, 10-19) to 1.72±0.89° (range, 0-3) postoperatively which was maintained till the final follow-up 2.16±0.98° (range, 0-4). In SSFIS group, also the correction of LKA was significant from preoperative to postoperative and maintained till the final follow-up (14.48±1.53° (range, 12-18), 1.76±1.01° (range, 0-3), 2.16±1.06° (range, 0-4), respectively) (Table 2, Figure 3). This was the same, considering the anterior vertebral height loss, where there was significant correction within each group, but with insignificant difference between the two groups. The preoperative AVHL in the LSF (35.33±6.77) (range, 22.69-49.25) was significantly corrected postoperatively to 10.78±4.05 (range, 4.08-22) and maintained till the final follow-up (11.62±4.02) (range, 5-22). In the SSFIS group, the fractured vertebral height

was also corrected, where the mean AVHL was significantly changed from 36.11±6.54 (range, 22.39–48.56) to 10.81±3.79 (range, 4.08-22) and maintained till the final follow-up (11.92±3.43) (range, 6-22) (Table 3, Figure 4)

The mean follow-up period of our patients was 13.5±2 (range, 12-15) months. There was a significant improvement in the back pain in both groups, as shown in the improvement in VAS (Figure 5) from 8.6±0.57 in LSF and 7.88±0.88 in SSFIS one month postoperatively to 1.32±0.8 and 1.48±0.65, respectively, at final follow-up (P<0.001). Comparing the early one-month VAS in the two groups, there was significant difference in favor of the SSFIS. Function outcome of the patients improved in the form of changes in the 3-month postoperative ODI of the LSF patients from 71.2±4.39 to 17.6±3.83 and in SSFIS group from 70.96±4.51 to 16.96±4.24 at the final follow-up (Figure 6).

In long-segment fixation group two patients (8%) developed wound infection, one presented with superficial infection and was treated by antibiotics and repeated dressing, while the other presented with deep infection which needed debridement and secondary sutures. In short-segment fixation group only one patient (4%) developed wound infection, which was treated by antibiotics and repeated dressing.

Table 1. Demographic data of the two groups.

Parameters		LSF(N=25)	SSFIS(N=25)	Test	*P*
Age (years)		32.88±4.61	34.00±4.56	-0.863[a]	0.392
Sex	Male	15	17	0.347[b]	0.556
	Female	10	8		
Fracture level	T11	3	2	0.804[b]	0.849
	T12	10	8		
	L1	10	12		
	L2	2	3		
TLICS	4	4	2	0.810[b]	0.667
	5	13	15		
	6	8	8		
PreLKA (degree)		14.20±2.06	14.48±1.53	-0.545[a]	0.588
PreAVHL (percent)		35.33±6.77	36.11±6.54	-0.414[a]	0.680

Quantitative data are expressed as mean±SD; qualitative data are expressed as number and percent (%); [a] independent samples Student's *t*-test; [b] Pearson Chi-Square test; P<0.05 is significant. LSF: long-segment fixation; SSFIS: short-segment fixation with intermediate screw; TLICS: Thoracolumbar Injury Classification Scoring; PreLKA: preoperative local kyphotic angle; PreAVHL: preoperative anterior vertebral height loss %.

Table 2. Changes in local kyphotic angle.

Parameters	Preoperative	Postoperative			Test	*P*
		3 months	6 months	Final		
LSF	14.48±1.53	1.76±1.01	1.92±0.99	2.16±1.06	63.857[a]	<0.001
SSFIS	14.20±2.06	1.72±0.89	2.00±0.92	2.16±0.98	62.679[a]	<0.001
Test	-0.713[b]	-0.203[b]	-0.325[b]	-0.020[b]		
P	0.476	0.839	0.745	0.984		

Quantitative nonparametric data are expressed as mean±SD and median; [a] Friedman test;
[b] Mann-Whitney *U* test; P<0.05 is significant. LSF: long-segment fixation; SSFIS: short-segment fixation with intermediate screw.

Table 3. Changes in anterior vertebral height loss %.

Parameters	Preoperative	Postoperative			Test	*P*
		3 months	6 months	Final		
LSF	35.33±6.77	10.78±4.05	11.18±3.83	11.62±4.02	440.090[a]	<0.001
SSFIS	36.11±6.54	10.81±3.79	11.29±3.61	11.92±3.43	606.061[a]	<0.001
Test	-0.414[b]	-0.027[b]	-0.101[b]	-0.283[b]		
P	0.680	0.979	0.920	0.779		

Quantitative data are expressed as mean±SD; [a]repeated measures ANOVA test; [b]independent samples Student's *t*-test; P<0.05 is significant. LSF: long-segment fixation; SSFIS: short-segment fixation with intermediate screw.

Table 4. Improvement in the VAS for back pain.

Parameters	1 month	6 months	Final	Test	*P*
LSF	8.60±0.57	2.04±0.84	1.32±0.80	45.422[a]	<0.001
SSFIS	7.88±0.88	2.00±0.86	1.48±0.65	44.356-[a]	<0.001
Test	-2.983[b]	-0.186[b]	-0.656[b]		
P	<0.05	0.853	0.512		

Quantitative nonparametric data are expressed as mean±SD and median; [a]Friedman test; [b] Mann-Whitney *U* test; P<0.05 is significant. VAS: Visual Analogue Scale; LSF: long-segment fixation; SSFIS: short-segment fixation with intermediate screw.

Table 5. Functional Improvement in ODI

Parameters	3month	6 months	Final	Test	*P*
LSF	71.2±4.39	21.68±3.35	17.6±3.83	2279.45[a]	<0.001
SSFIS	70.96±4.51	19.92±4.70	16.96±4.24	1748.18[a]	<0.001
Test	0.190[b]	1.523[b]	0.560[b]		
P	0.850	0.135	0.578		

Quantitative parametric data are expressed as mean±SD; [a]repeated measures ANOVA test; Independent Sample *t*-test [b]; P<0.05 is significant. ODI: Oswestry Disability Index; LSF: long-segment fixation; SSFIS: short-segment fixation with intermediate screw.

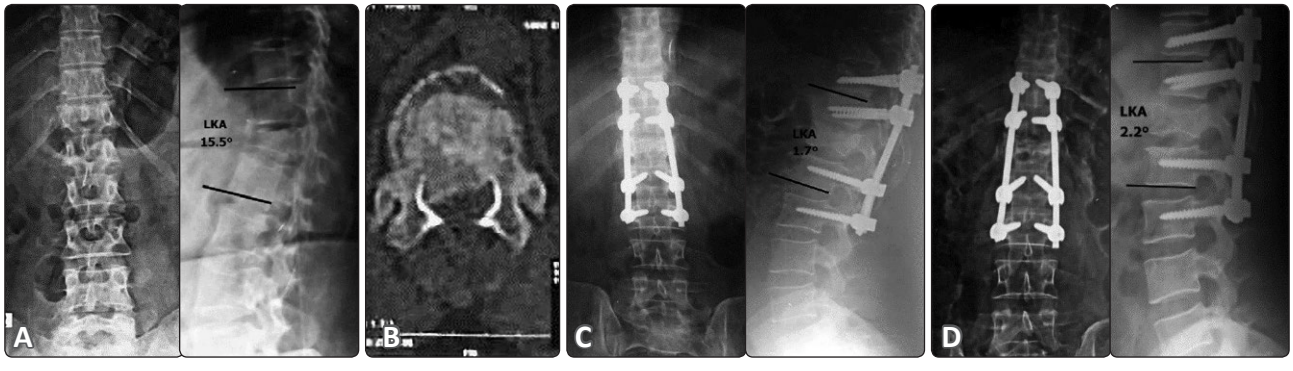

Figure 1. Male patient, 31 years old, with A3 fracture of T12. He was treated by long-segment fixation from T10 to L2. Preoperative (A) plain X-rays (LKA 15.5°, AVHL% 30.7%); (B) CT scan. Postoperative (C) plain X-rays (LKA 1.7°, AVHL% 10.2%); (D) final follow-up plain X-rays (LKA 2.2°, AVHL% 12.8%).

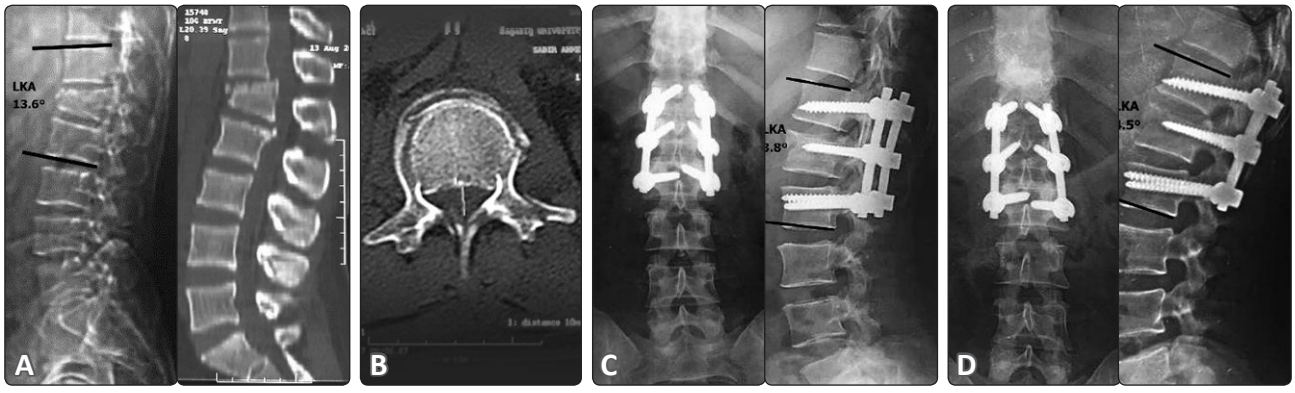

Figure 2. Male patient, 32 years old, with A3 fracture of L1. He was treated by short-segment fixation from T12 to L2 with intermediate screw. Preoperative (A) plain X-rays (LKA 13.6°, AVHL% 34.1%); (B) CT scan. Postoperative (C) plain X-rays (LKA 3.8°, AVHL% 10.9%); (D) final follow-up plain X-rays (LKA 4.5°, AVHL% 12.1%).

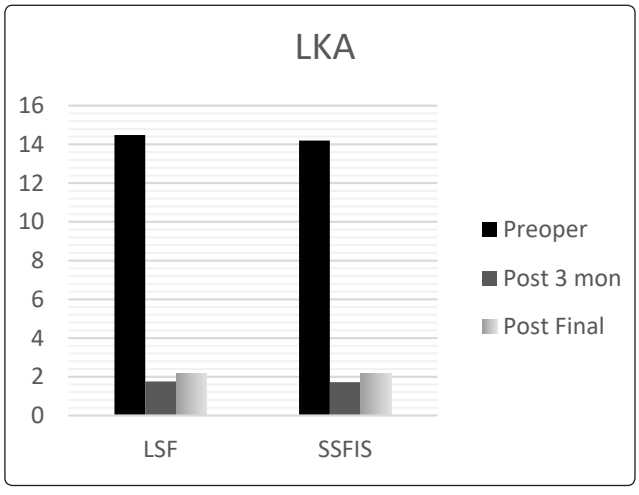

Figure 3. Changes in the local kyphotic angle.

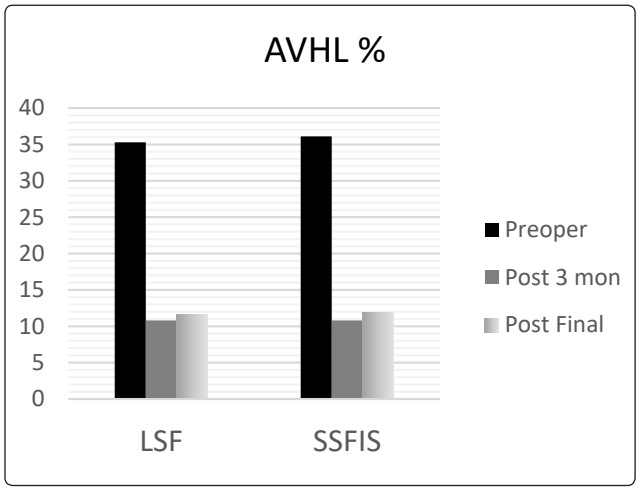

Figure 4. Changes in the anterior vertebral height loss.

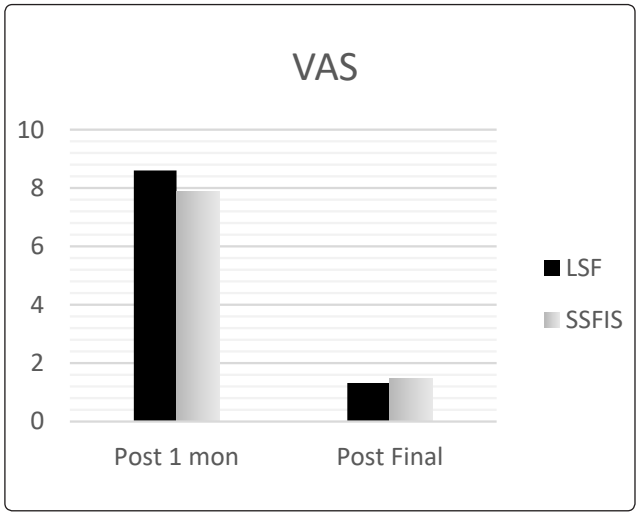

Figure 5. Improvement in the VAS for back pain.

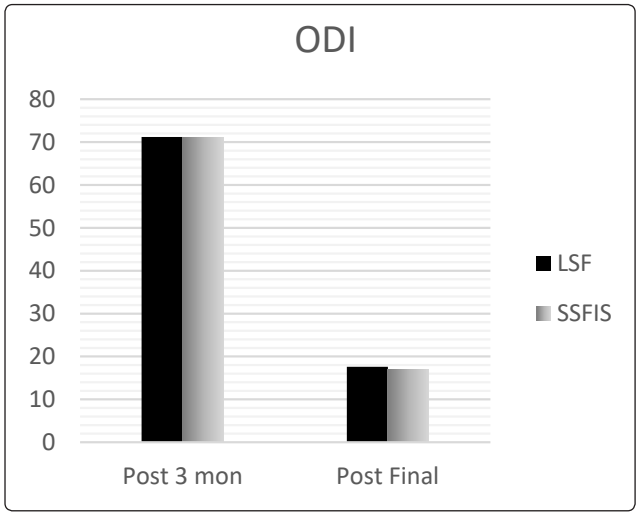

Figure 6. Improvement in the ODI score.

DISCUSSION

In the present study, fifteen patients with burst thoracolumbar fractures were divided into two groups according to the number of instrumented levels, long-segment fixation group, and the short-segment fixation and intermediate screws group. Both groups showed satisfactory changes in radiological parameters, where the local kyphotic angle and the anterior vertebral height loss were corrected significantly comparing preoperative to postoperative and maintained to the final follow-up. Neither significant loss of correction nor implant failure was encountered in both groups.

Burst fractures are the most common types of thoracolumbar spine fracture. The main goal of fracture fixation is correcting the local kyphotic deformity developed at the time of injury, early mobilization of the patient, decreasing the hospital stay, and preventing posttraumatic complications from prolonged recumbency and from loss of correction. The popularity of the posterior surgical fixation of the thoracolumbar fractures increased after the introduction of the transpedicular screws fixation.[10,20] Biomechanically, it controls the vertebrae by providing three-column fixation and helps in support against loads, thus preventing loss of correction and deformity.[2,12]

Several studies try to figure out the appropriate number of vertebrae fixation used in the treatment of the burst fracture.[18] They reported increasing implant failure and loss of correction in short-segment fixation with progressive kyphosis[7] in comparison to long-segment fixation in thoracolumbar fractures. They assumed that loss of the anterior column support was the main reason of failure.[1,11] Sapkas et al.[15] reported that both long- and short-segment fixation showed satisfactory reduction of the kyphotic deformity, but they assumed that the long-segment fixation had a better long-term result concerning the radiological parameters and the patient satisfaction.

Mahar et al.[9] studied biomechanically the stability provided by adding a screw in the fractured vertebra and they found that this additional fixation point helps in stabilizing the fixation construct and helps in fracture reduction and correction of the deformity. This was supported by other studies comparing different pedicle screws configuration and all stated that adding an additional screw in the fractured vertebra increases the rigidity and the stability of the fixation construct.[2,12]

These results were against the results of McLain et al.[11] and Waqar et al.[19] who reported loss of correction and implant failure in the short-segment group, but they do not use intermediate screws in the fractured levels and they studied different types of thoracolumbar fractures and fracture dislocations which was not the case in our study where we included only types A3 and A4 AOSpine thoracolumbar fractures.

Our results concurred with Dobran et al.[3] who included sixty patients with thoracolumbar fractures in two groups, one fixed with six screws construct and the other treated with eight screws construct with exclusion of the fractured level. They reported an overall correction of the posttraumatic kyphosis and restoration of the vertebral height at the postoperative period with no significant difference between both groups and there was no significant difference between the two groups in terms of correction loss at the last follow-up too.

Pellisé et al.[14] validated the long-term results of the short-segment fixation with inclusion of the fractured level in eighty-six patients with thoracolumbar burst fracture and stated that this technique can provide effective reduction of the traumatic deformity and provide long-term maintenance of reduction with no significant loss in reduction. They also pointed out the validity of the load-sharing classification in predicting the outcome.

Other studies[4,5] stated that the use of screws in the fractured vertebra with short-segment fixation provides correction of kyphosis comparable to long-segment fixation. The loss of correction in one of these studies[5] was correlated to the amount of initial angle correction in the early postoperative and it did not exceed 7° loss in the last follow-up in the short-segment fixation. This was not the case in our study where the loss of kyphotic correction was insignificant between the early postoperative

and final follow-up. This may be due to the use of the monoaxial screws in our study like the study of El-Sharkawi et al.[4] that used also monoaxial screws in the fixation of the vertebra and reported few degrees of correction loss in both long- and short-segment groups between the initial correction and final follow-up and it was statistically insignificant.

Theoretically, decreasing the number of fixed levels will lead to better patient surgical outcome considering postoperative pain and function even if loss of correction in short-segment occured.[7] In our patients, there was considerable correction of VAS for back pain and the ODI scores in both groups with no significant difference between the two groups at the final follow-up. The significant correction of the VAS in the short-segment group compared to the long-segment one in the early postoperative period may be due to the less soft tissue dissection and smaller wounds needed to apply the screws.

The restoration of the patients' functional outcome after short-segment fixation was confirmed in Yang et al.[21] study. They evaluate the improvement of the ODI score of sixty-four patients with single-level thoracolumbar burst fracture treated with short-segment fixation and reported average ODI score of 16.7 and Denis pain score improvement at the final follow-up.

Tezeren and Kuru[16] compared the long-segment fixation with the short-segment one and stated that although there was significant loss in correction in the short-segment group with more than 10° in comparison with the long-segment group, both groups showed excellent scores in the Low Back Outcome Score with an average LBOS of 61.3 in the SS group and 63.4 in the LS group with no significant difference.

The complication rate is low in our study with three patients with wound infection in both groups; one case needed debridement and secondary sutures in the long-segment fixation group. No implant failure occurred in both groups till the final follow-up. This was opposite to other studies, which studied the short-segment fixation without the use of intermediate screws and reported failure in constructs in the form of screws pullout and metal breakage.[11,19]

Our study has some limitations in the form of small sample size in both groups and the nonrandomization of the patients in both groups, but we tried to keep the homogeneity of the demographic criteria of our patients.

CONCLUSION

Intermediate screw applied in the fractured level in management of thoracolumbar burst fracture improves the correction and maintenance of local kyphosis in short-segment fixation like long-segment construct with saving vertebral motion levels from being fixed. More randomized controlled and multicenter studies are needed to support these findings.

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الملخص العربي

هل يستطيع تثبيت الفقرة المكسورة في كسور الفقرات الصدرية القطنية المحافظة علي المستويات المتحركة بالفقرات؟ دراسة مقارنية بين التثبيت الطويل و التثبيت القصير مع تثبيت الفقرة المكسورة

البيانات الخلفية: يعد علاج كسور الفقرات الصدرية القطنية بواسطة الثبيت الخلفي بالمسامير الجزع نخاعية هو اكثر طرق العلاج شيوعا ولا يزال علاج هذه الكسور مثاراً للجدل من حيث عدد الفقرات المستغلة في التثبيت، حيث يشتهر التثبيت القصير بعدم الثبات في علاج هذه الحالات. و لقد ثبت حديثاً أن تثبيت الفقرة المكسورة يزيد من صلابة جهاز التثبيت القصير مما يقلل عدد الفقرات المستغلة في التثبيت.

الغرض: مقارنة النتائج النهائية للتثبيت الطويل و التثبيت القصير مع تثبيت الفقرة المكسورة في علاج كسور الفقرات الصدرية و القطنية

تصميم الدراسة: هذا البحث هي دراسة مستقبلية مقارنية.

المرضى و الطرق: تناول في هذا البحث علاج خمسون مريضا يعاني من كسور الفقرات الصدرية القطنية في الفترة من 2009 إلي 2014، و لقد تم تقسيم المرضي إلي مجموعتين علي حسب عدد الفقرات المثبتة في العلاج حيث تكونت كل مجموعة من 25 مريض، المجموعة الأولي تثبيت طويل (فقرتين فوق الكسر و إثنين تحت الكسر) و المجموعة الثانية تثبيت قصير مع تثبيت الفقرة المكسورة، و تم متابعة التحسن في درجة التحدب وارتفاع الفقرة بعد العمليات و حتي نهاية المتابعة، كما تم متابعة مستوي الألام (VAS) و المضاعفات الناتجة عن التثبيت.

النتائج: أظهرت المؤشرات الإحصائية أنه تقريبا لا يوجد اختلاف ما بين المجموعتين قبل العملية في البيانات الديموغرافية و أيضا في درجة إصلاح التحدب و استيعاد الفقرة المكسورة لارتفاعها السابق بعد العمليات و حتي نهاية فترة المتابعة. لم يحدث مضاعفات خطيرة بعد العمليات في كلتا المجموعتين من حيث ثبات المسامير مع التحسن الاكلينيكي و الوظيفي المقاس للمرضي بواسطة طريقة فاز (VAS) و طريقة أوزويستري (ODI).

الاستنتاج: يتضح من هذه الدراسة أن النتائج السريرية والإشعاعية للتثبيت القصير لكسور الفقرات الصدرية القطنية مع تثبيت الفقرة المكسورة تكاد تكون مقارنة بنتائج التثبيت الطويل لنفس الحلات مع المحافظة علي عدد من الفقرات دون الحاجة إلي تثبيتها مما يحسن من مقايس الألم و نشاط الحياة اليومية للمرضى.