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Review Article

Comparison of short-segment versus long-segment fixation for the treatment of thoracolumbar burst fracture: a meta-analysis

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Abstract: *Background*: Thoracolumbar burst fracture is one of the most common spinal traumas. It was still indeterminate whether short-segment (SS) fixation was more effective and preferable than long-segment (LS) fixation. We therefore conducted this meta-analysis to assess the comparative safety and efficacy of SS and LS fixation for the treatment of thoracolumbar burst fracture. *Methods:* A literature search was conducted between January 1990 and September 2014. The sources of electronic searching included EMBASE, PubMed, Google Scholar, Ovid, Cochrane Library and Springer. Study eligibility was based on predefined criteria. The data were extracted by two authors independently and were managed using the Review Manager (RevMan) 5.2. A meta-analysis was conducted under the suggestion of PRISMA guideline standards. *Results:* Finally only 8 eligible articles were included in the current study, including a total of 455 thoracolumbar burst fracture patients who underwent the treatment with SS fixation (n=239) and LS fixation (n=216). The outcomes of this study indicated that final outcome in regard to implant failure, anterior body height loss (ABHL), cobb angle (CA) and restoration ratio of compromised canal is better in the LS fixation group than those of SS fixation group. However, SS group significantly reduced surgical time when compared with LS group. There was no significant difference regarding blood loss, complication rate, Sagittal Index (SI) and kyphotic angle (KA). *Conclusions:* The main results of radiographic indexes and implant failure are better in the LS fixation group than those of SS fixation group. Nevertheless, LS fixation prolonged the duration of operation. Clinical outcomes suggested that there was no difference between the SS and LS fixation. The choice of the appropriate method has to be made cautiously and on an individualized basis.

Keywords: Thoracolumbar burst fracture, short-segment, long-segment, meta-analysis

Introduction

Thoracolumbar burst fractures, which count for 10%-20% of spinal fractures, are common spinal traumas that comprise serious instability of vertebral column and spinal canal compression, resulting in increased hazards of neurological deficits, kyphosis and osteoporosis of the spine [1]. A number of studies have proved good therapeutic effect of thoracolumbar burst fractures [2-4]. A consensus has been reached by the majority of experts that surgical therapy is necessary for symptomatic, unstable burst fractures [5, 6], nevertheless, it is still controversial with respect to the best surgical approach for thoracolumbar burst fractures [7-12].

The objectives of surgical treatment for thoracolumbar burst fractures are to reestablish stability of the vertebral column as well as to decompress the spinal canal, which is the foundation of early mobilization [7-12]. Among all the surgical modalities, posterior transpedicular screw fixation has been more preferable when dealing with thoracolumbar burst fractures [15, 16].

Pedicle screws were introduced for the treatment of thoracolumbar fractures by Roy-Camille et al [17]. In 1963 and developed by Dick et al [18] in 1985, since then, transpedicular SS fixation has become increasingly prevalent [18]. This modality involves pedicle screw fixation at one vertebra above and one vertebra below the fracture. However, it has been demonstrated that SS fixation is in relation to unacceptable implant failure rate, inadequate stability and postoperative loss of kyphosis correction [7, 8, 20]. Additional transpedicular procedures such as vertebroplasty and bone graft to maintain the anterior column has been provided as one of the choices to avoid this failure [21-24]. An alternative is to use longer segmental instrumentation to reduce the load on each screw. Hence, performing posterior fixation with two or more segments above and below the fractured vertebra appears to be associated with less rate of failure, yet significant increased vertebral immobility, dorsalgia and implant failure was also detected in LS fixation [11, 13, 19, 25]. Therefore, it was still indeterminate whether SS fixation was more effective and preferable than LS fixation. So we conduct this meta-analysis, trying to systematically assess the comparative safety and efficacy of SS fixation and LS fixation for the treatment of thoracolumbar burst fracture with the best available evidence.

Methods

Study selection criteria

Study eligibility was based on predefined criteria. Allowing for the fact that only a small number of randomized controlled trials were available in the literature, non-randomized comparative studies (retrospective and prospective) were also included. The eligibility criteria were as follows: 1) the study included a comparative design of SS fixation versus LS fixation in patients with thoracolumbar burst fracture; 2) patients without confirmed pathological thoracolumbar burst fractures according to imaging results; and 3) at least one of the following outcomes should be reported: perioperative results (operative time, blood loss, or hospital stay), kyphotic angle, sagittal index, anterior body height loss (ABHL), cobb angle, implant failure or complications. Studies were excluded if they 1) included patients who had thoracolumbar surgery in the previous 12 months; 2) reported insufficient data, e.g. did not report measures of variability. Lead authors were contacted in order to achieve additional data as required.

Literature search and data sources

A literature search was conducted between January 1990 and September 2014. The sources of electronic searching included EMBASE, PubMed, Google Scholar, Ovid, Cochrane Library and Springer. The initial key words used were "thoracolumbar burst fracture", with the search limited to "short-segment fixation versus long-segment fixation". Other key words that were used (without any search limitations) were "fixation of thoracolumbar burst fractures", "treatment of thoracolumbar burst fractures with various segment stabilization" and "different instrumentation strategies for fractured thoracic and lumbar spine". Additionally, conference full text articles were also reviewed to identify more articles. The results of unpublished studies were not sought.

Data extraction

The data were extracted by two authors independently based on the following categories: 1) Study year, country and study design; 2) Basic study characteristics including patients' inclusion/exclusion criteria, enrolled number, age and sex proportion; 3) Baseline comparison information of confounding factors, such as diagnosis, surgical level and concomitant diseases; 4) Surgical information, including detailed spinal level and numbers, instrumentation and bone graft; 5) Perioperative outcomes such as operative time, blood loss, and hospital stay; 6) Imaging outcome improvement at last follow-up, including kyphotic angle, sagittal index, anterior body height loss (ABHL), cobb angle and canal compromise; 7) Fusion assessment method, fusion success criteria, and fusion rate at last follow-up; 8) Complication types and complication rates. Any differences were determined by consensus at the conclusion of full text review.

Data synthesis and statistical analysis

Data were managed using the Review Manager 5.2, a software provided by Cochrane Centre. Dichotomous outcomes (e.g. presence/absence of pain) were reported as proportions and were directly compared (difference in proportions). We used these proportions to calculate risk ratios (RRs) with 95% confidence intervals (CIs). For continuous data (e.g. kyphotic angle, sagittal Index, anterior body height loss (ABHL)), results are presented as weighted mean differences (WMD). The heterogeneity was explored using the chi-squared test with significance set at a *P*-value less than 0.05, and I^2 was used to estimate total variation across the studies. A fixed-effect model was

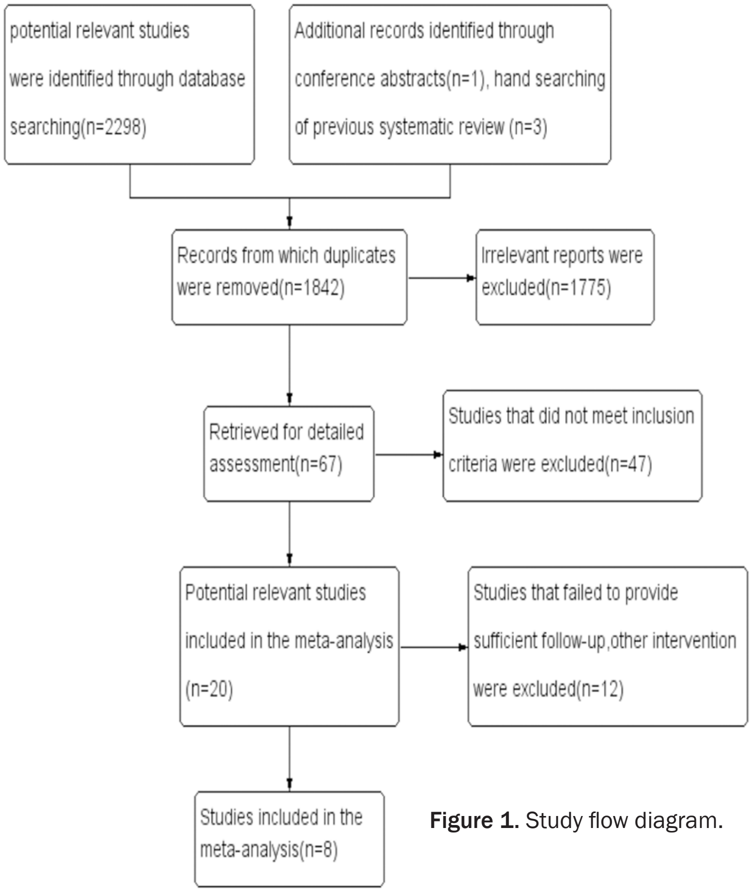

Figure 1. Study flow diagram.

adopted if there was no statistical evidence of heterogeneity, and a random-effect model was adopted if significant heterogeneity was evident. In addition, the review was conducted under the suggestion of PRISMA guideline standards [26]. The possibility of publishing bias was not evaluated because of the small number of studies assessed.

Search results

Firstly, a total of 2298 potentially relevant reports were identified through database searching (MEDLINE, n=186; PubMed, n=1692; Google Scholar, n=139; Ovid, n=110; Cochrane Library, n=46; Springer, n=125). 4 additional literatures identified through conference abstracts (n=1), hand searching of previous systematic review (n=3). After the duplicates were removed, 1842 potentially relevant studies were reserved, 1775 of which were excluded because they were not related to the thoracolumbar burst fracture. The full texts of the left 67 studies were assessed and 47 were excluded (24 only reported thoracolumbar burst fracture data while not for comparison of short and long segment fixation; 23 due to no available data). After a thorough review, 12 studies were eliminated as they failed to provide sufficient follow-up or received other intervention. Finally, only 8 eligible articles were included in current study. The flow chart of the study selection is shown in **Figure 1**. The eligible studies were published between 2003 and 2014 including a total of 455 thoracolumbar burst fracture patients who underwent the treatment with short segment (SS, n=239) and long segment (LS, n=216) instrumentation. The age of the patients ranged from 13 to 70 years old. The smallest sample size was 18 and largest was 94. The follow-up time of the included studies was from 3 to 104 months.

Study characteristics

The study characteristics of the 8 trials included in the meta-analysis were summarized in **Table 1**, of which five are RCSs (retrospective comparative studies) [8, 10, 13, 25], two are PCSs (prospec-tive comparative studies) [7, 11] and 2 are RCTs (randomized controlled trials) [9, 19]. The male to female ratio is 1.65:1. The mean age was 40.2 years. The mean follow-up duration ranged from 13.73 to 49.75 months. 93.6% of the fractures were located at T11 to L2 level. The cause of injury were reported in five studies, among which falls from the height and motor vehicles accidents were the top two inducements. Preoperative spinal Canal encroachment were observed in two studies [8, 13] and anterior body height loss were assessed in six studies [7, 9-11, 19, 25]. Four papers provided information about preoperative kyphotic angle [8, 10, 19, 25]. The main complications reported in the included studies were implant failure and donor site pain.

Operative time

Four studies investigated significant reduced surgical time in the SS group (**Figure 2**). All

Table 1. The study characteristics of the trials that included in the meta-analysis

Study	Year	Country	Study Design	No.of patients (SS:LS)	Mean follow up (month)	Mean age (SS:LS)	Gender (M:F)	Location of Fracture	Causes of Injury
Moon MS, et al [19]	2003	Korea	RCT	42 (18:24)	32-72	34.5	33:9	T12 (n=6), L1 (n=15), L2 (n=12) L3 (n=3), L3-4 (n=6), L4-5 (n=3)	Falls from a height (n=30), Slip injuries on stairs (n=3) Hang glider crashes (n=3), Traffic injuries (n=3) Industrial injuries (n=3)
Gregory F, et al [25]	2004	America	RCS	RCS	52	31 (17-70)	24:16	T11 (n=1), T12 (n=4), L1 (n=13) L2 (n=11), L3 (n=7), L4 (n=4), L5 (n=1)	Falls from a height (n=21), Motor vehicle accidents (n=16), Heavy object landing (n=3)
Gunduz T, et al [7]	2005	Turkey	PCS	18 (9:9)	29.6	33.4 (17-56)	15:3	T12 (n=3), L1 (n=14), L2 (n=1)	Motor vehicle accidents (n=14), Secondary to falls (n=3) Sustained injuries during a building collapse (n=1)
Murat A, et al [8]	2007	Turkey	RCS	63 (32:31)	34.4	34.4	37:26	T12-L2	NA
Lee SH, et al [9]	2009	Korea	RCT	36 (26:10)	36 (26:10)	47.5	47.5	T8 (n=1), T12 (n=5), L1 (n=15) L2 (n=6), L3 (n=7), L4 (n=2)	Fall from height (n=24), slip (n=6), Direct trauma (n=4) Car accident and pedestrian accident (n=1)
Wu Y, et al [23]	2009	China	RCS	27 (12:15)	29.6	32.6:36.8	NA	T11-L2	NA
Kim HS, et al [10]	2009	Korea	RCS	94 (62:32)	21	39.5:41.2	64:30	T11 (n=3), T12 (n=12), L1 (n=38), L2 (n=41)	NA
George S, et al [11]	2010	Greece	PCS	50 (20:30)	35	32	32:18	T11 (n=6), T12 (n=16), L1 (n=23) L2 (n=5), L3 (n=3)	Automobile (n=28), Occupational (n=11) Motorcycle (n=8), Horse (n=3)
Umut C, et al [13]	2014	Turkey	RCS	25 (10:15)	72.3	32.3:36	11:14	T12 (n=7), L1 (n=14), L2 (n=4)	NA

RCS: retrospective comparative study, PCS: prospective comparative study, RCT: randomized controlled trial, NA: not available.

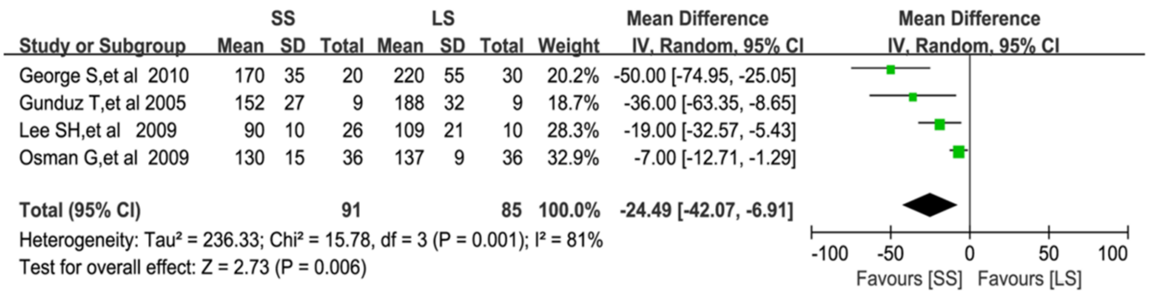

Figure 2. Forest plot of comparison: operative time.

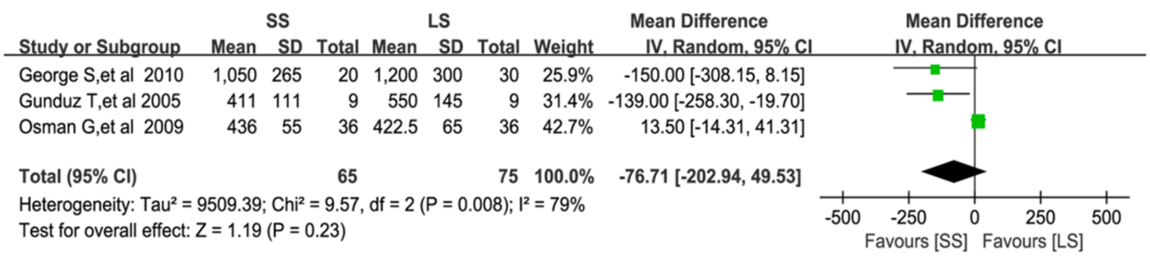

Figure 3. Forest plot of comparison: blood loss.

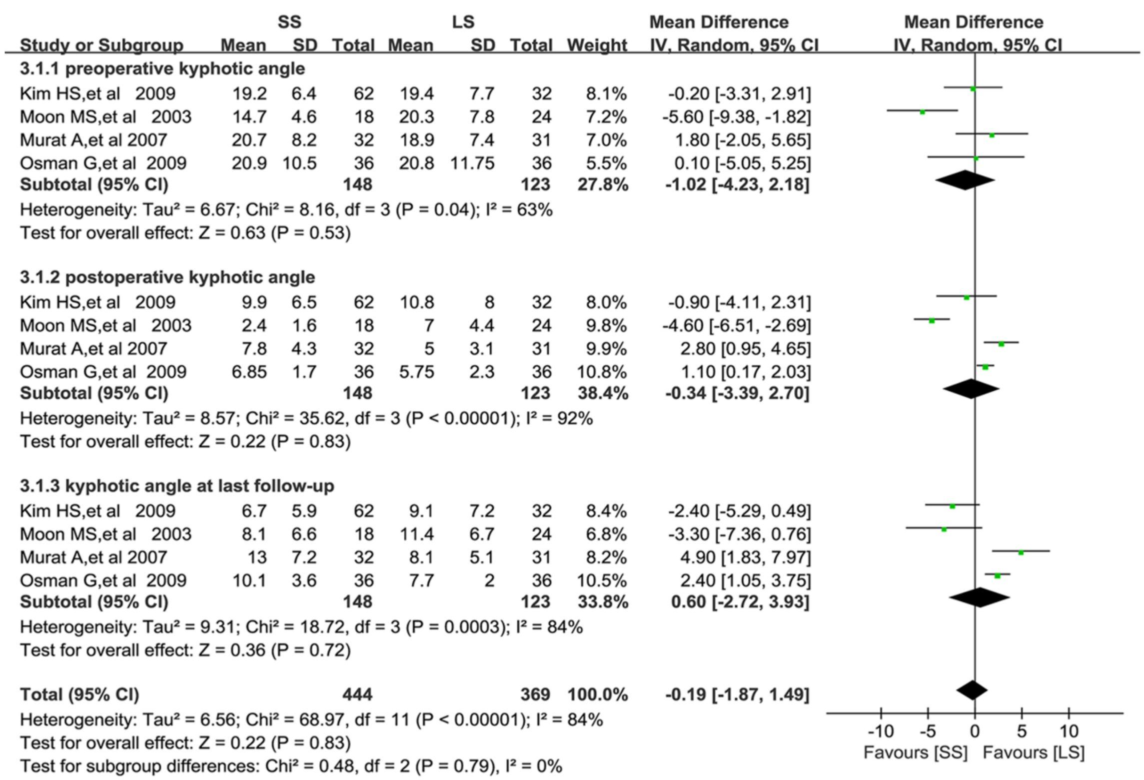

Figure 4. Forest plot of comparison: kyphotic angle.

studies showed SS group significantly reduced surgical time when compared with LS group. Overall, the WMD was -24.49 (95% CI: -42.07 to -6.91, P=0.006) in favor of the SS group. There

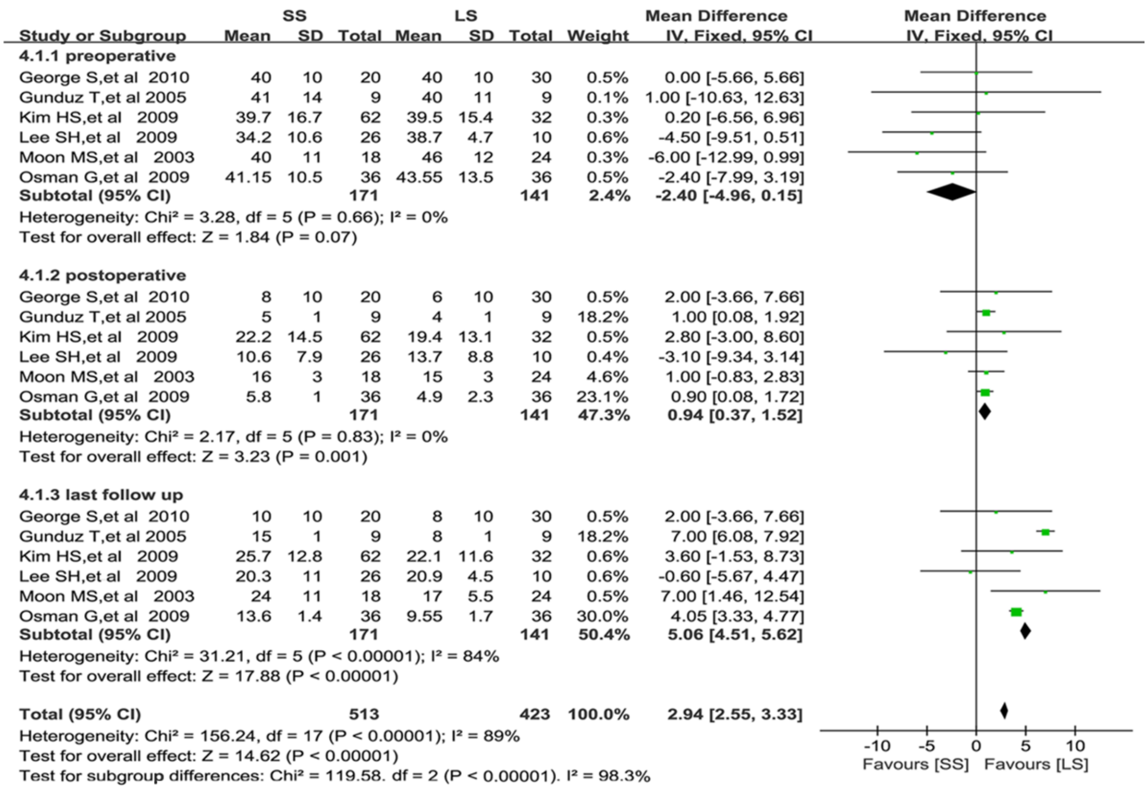

Figure 5. Forest plot of comparison: anterior body height loss.

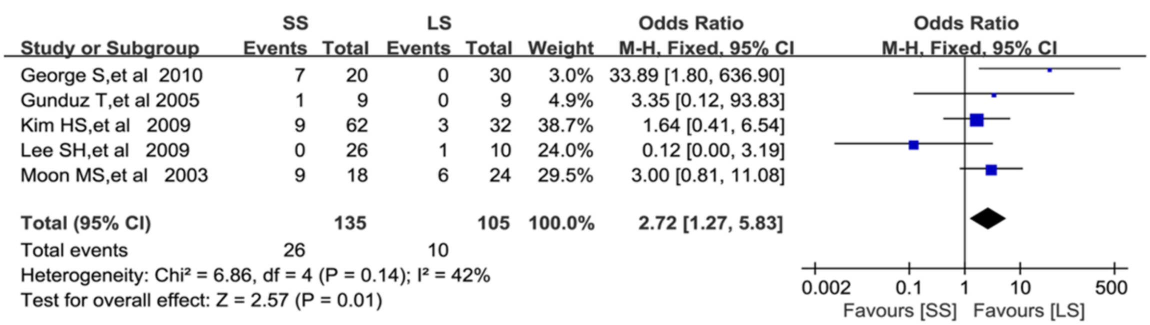

Figure 6. Forest plot of comparison: implant failure.

was obvious evidence for statistically significant heterogeneity (I^2=81%; P=0.001).

Blood loss

Three trials reported perioperative blood loss (**Figure 3**) [7, 11, 25]. Pooling of relevant data showed no statistically significant difference between the two groups, the WMD was -76.71 (95% CI: -202.94 to 49.53, P=0.23). There was obvious evidence for statistically significant heterogeneity (I^2=79%; P=0.008).

Kyphotic angle (KA)

Information of kyphotic angle was extracted from four trials (**Figure 4**) [8, 10, 19, 25]. In each trial, the difference was not significant between the two groups with regard to preoperative kyphotic angle (WMD=-1.02, 95% CI: -4.23 to 2.18, P=0.53), postoperative kyphotic angle (WMD=-0.34, 95% CI: -3.39 to 2.70, P=0.83) and kyphotic angle at last follow-up (WMD=0.60, 95% CI: -2.72 to 3.93, P=0.72). There were obvious evidence for statistically

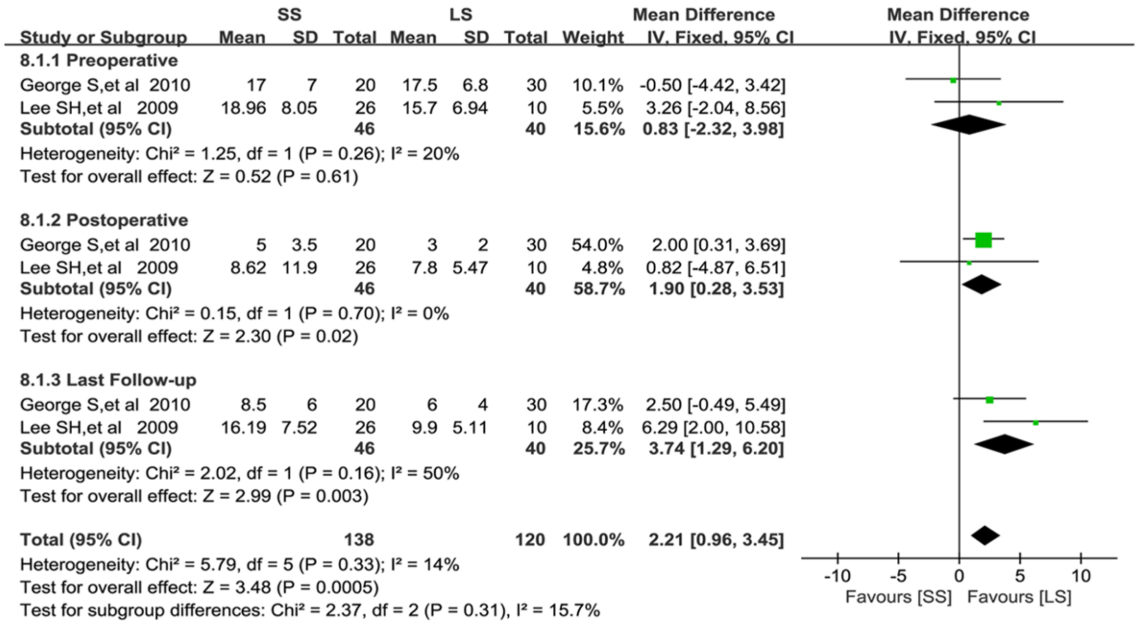

Figure 7. Forest plot of comparison: Cobb Angle.

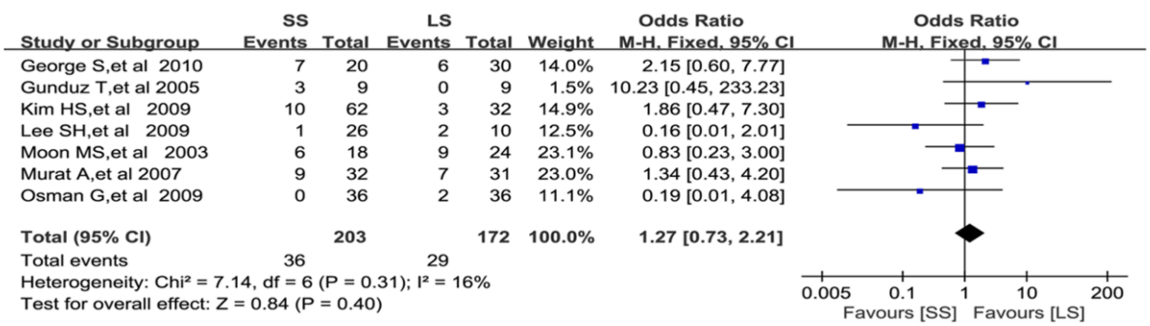

Figure 8. Forest plot of comparison: complications.

significant heterogeneity in preoperative, postoperative and last follow-up ABHL results (I^2=63%; P=0.04, I^2=92%; P<0.00001 and I^2=84%; P=0.0003 separately).

Anterior body height loss (ABHL)

Anterior body height loss were assessed in seven eligible studies (**Figure 5**) [7, 9-11, 19, 25]. Pooled estimates also revealed no significant difference in preoperative ABHL between the two groups (WMD=-2.40, 95% CI: -4.96 to 0.15, P=0.07), whereas the ABHL at postoperative and last follow-up in LS group were less than those of SS group, the statistical difference were significant (WMD=0.94, 95% CI: 0.37 to 1.52, P=0.001 and WMD=5.06, 95% CI: 4.51 to 5.62, P<0.00001 respectively). There was no obvious evidence for statistically significant heterogeneity in preoperative and postoperative ABHL (I^2=0%; P=0.66 and I^2=0%; P=0.83 separately), while moderate heterogeneity existed among the last follow-up results (I^2=84%, P<0.00001).

Implant failure

Data regarding implant failure were documented in five studies (**Figure 6**) [7, 9-11, 19]. The participants in LS group were at a statistically significant lower risk to undergo implant failure than that of SS groups (RR=2.72, 95% CI: 1.27 to 5.83, P=0.01). There was moderate obvious evidence for significant heterogeneity (I^2=42%; P=0.14).

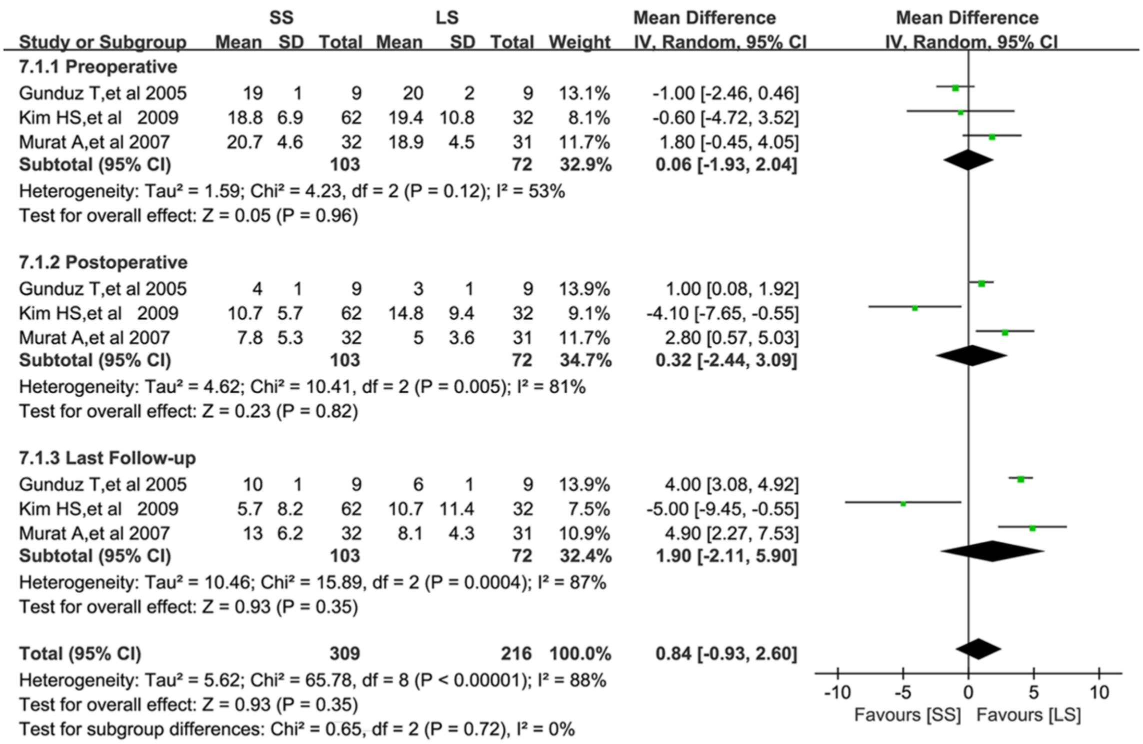

Figure 9. Forest plot of comparison: sagittal index.

Cobb angle (CA)

Two of the included studies provided data on cobb angle (**Figure 7**) [9, 11]. The difference was not significant between the two groups in preoperative results (WMD=0.83, 95% CI: -2.32 to 3.98, P=0.61), nevertheless the Cobb Angles at postoperative and last follow-up in LS group were smaller than those of SS group, the statistical difference were significant (WMD= 1.90, 95% CI: 0.28 to 3.53, P=0.02 and WMD=3.74, 95% CI: 1.29 to 6.20, P=0.003 respectively). There was no obvious evidence for statistically significant heterogeneity in preoperative and postoperative results (I^2=20%; P=0.26 and I^2=0%; P=0.70 separately), while moderate heterogeneity existed among the last follow-up results (I^2=50%, P=0.16).

Complications

Seven studies [9, 11] reported data on the total number of complications (including implant failure, nerve root injuries, deep wound infections and reoperation etc.) (**Figure 8**). Total complications rates did not differ significantly between SS and LS group (17.8% and 16.9%, respectively; P=0.40, RR=1.27, 95% CI: 0.73 to 2.21), and heterogeneity between studies was not significant (I^2=16%, P= 0.31).

Sagittal index (SI)

Data on SI were available from three studies (**Figure 9**) [7, 8, 10]. No significant differences was detected between the two groups with regard to preoperative SI (WMD=0.06, 95% CI: -1.93 to 2.04, P=0.96), postoperative SI (WMD=0.32, 95% CI: -2.44 to 3.09, P=0.82) and SI at last follow-up (WMD=1.90, 95% CI: -2.11 to 5.90, P=0.72). There were obvious evidence for statistically significant heterogeneity in preoperative, postoperative and last follow-up SI results (I^2=53%; P=0.12, I^2=81%; P=0.005 and I^2=88%; P<0.00001 separately).

Canal compromise

Data regarding canal compromise were documented in two studies (**Figure 10**) [8, 13]. No significant differences was detected between the two groups in preoperative and last follow-up results (WMD=-2.03, 95% CI: -5.91 to 1.84, P=0.03 and WMD=2.78, 95% CI: -0.77 to 6.32, P=0.12 respectively) while the restoration ratios in LS group were higher than those of SS

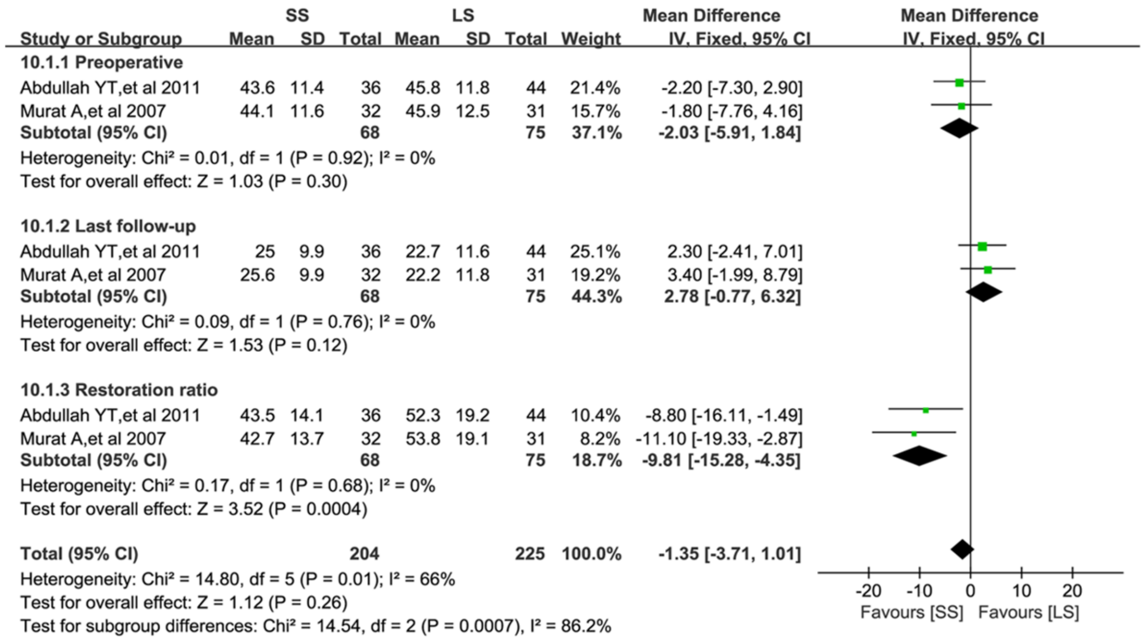

Figure 10. Forest plot of comparison: canal compromise.

group, the statistical difference were significant (WMD=-9.81, 95% CI: -15.28 to -4.35, P=0.0004). No obvious heterogeneity was detected in each subgroup results (I^2=0%, P=0.92; I^2=0%, P=0.76 and I^2=0%, P=0.68 separately).

Discussion

There are numerous matters to be taken into account in the disposal of patients with thoracolumbar burst fractures. Prime disposal issues comprise medical stabilization, immobilization and acquisition of spinal alignment. Decisive therapeutic strategies are based on treatment expenses, spinal stabilization at the injured area, and the requirement for nerve decompression, followed by proper rehabilitation to optimize the patient's functional recovery. It was demonstrated that the indirect expenses of conservative management outnumber the direct expenses up to now, make up 95.4% of the total expenses, which is 71.6% in surgical therapy [27]. Allowing for cost efficiency, the surgical therapy of thoracolumbar burst fractures is more preferable. Nevertheless, the optimal surgical approaches for the treatment of thoracolumbar burst fractures remains controversial.

Short segment (SS) fixation has been extensively used by surgeons throughout the world in previous decades [28, 29]. and has been frequently regarded as prefered surgical option because it provides advantages such as fusing fewer motion segments, reducing operative time, decreasing perioperative bleeding as well as avoiding loss of lumbar lordosis that is associated with flat back syndrome [30, 31]. However, it was reported that SS fixation tend to bring about fairly high rates of implant failure, ranging from 9% to 54% [7, 8, 17, 32-36]. Lee SH et al [9]. Declared that LS pedicle instrumentation can reduce implant failure rate, but it also sacrifices additional motion segments and ultimately reduces the range of motion [8, 9, 37]. Our meta-analysis showed that the participants in LS groups was at a statistically significant lower risk to undergo implant failure than that of SS group.

In general, the most significant objective of the surgical intervention of thoracolumbar burst fractures is to switched back the patients' normal lives. Our review indicated that despite the SS fixation was associated with less incorporated motion segments, it was not associated with a greater enhancement in Mean Dennis Work Scores or a higher incidence of return to work. Among all the nine documented studies, only Gunduz T et al [7] reported Low Back Outcome Score(LBOS), which was devised by Fraser and Greenough [38], the results showed that there was no significant difference in pain reduction between SS and LS group. Murat Altay et al [8] demonstrated that restoration of canal compromise (CC) was well maintained in both SS and LS group, but the results were better in LS group and correction loss in LS group was much less than in SS Group. George S et al [11]. compared the back index in SS and LS instrumentation, but no statistically significant difference was detected between their preoperative and postoperative values.

In this meta-analysis, we found significant differences in duration of operation between the two groups. The LS group was associated with longer operative times, while use of the SS instrumentation could reduce the risks associated with longer duration of operation. Pooling of relevant data showed no statistically significant difference between the two groups regarding perioperative blood loss, in which the surgeon's proficiency, the size of the screws and internal anatomy would play a part [25]. Lee et al [39] concluded that easy cage insertion and conveniently designed expandable cage would enable to reduce the duration of operation and the amount of hemorrhage during operation.

Our meta-analysis also suggested that the main outcomes of the radiographic indexes studied are better in the LS fixation group than that of SS fixation group. The ABHL at postoperative and last follow-up in LS group were less than that of SS group, the statistical difference were significant. Several study also indicated that LS fixation can provide more secure fixation and better correction than SS fixation in unstable thoracolumbar burst fractures, therefore avoiding correction loss [40]. Some studies demonstrated that anterior column reconstruction via cement augmentation techniques in combination with short segment pedicle screw constructs was a useful modality for thoracolumbar burst fractures [41-43]. The difference was not significant between the two groups with regard to kyphotic angle, yet LS group showed better results in cobb angle and sagittal index at postoperative and last follow-up, the statistical difference were significant.

For complication rate, no significant differences were detected between the two groups. The inducements for complication were similar among the studies, including superficial infection, pedicle screw dislodgement or implant breakage and epidural hematoma. Lee SH et al [9]. reported two cases of implant removal in LS fixation group, as there was a risk of skin breakdown due to the irritation by the rods, and one case of screw breakage in SS fixation group.

We acknowledge that some limitations exists in our meta-analysis. Firstly, despite several relevant studies have been reported, the majority were small and of poor quality, all datas and subsequent analysis were on the basis of only 395 patients. Secondly, statistically significant heterogeneity was detected in the literatures especially when we incorporated the continuous outcomes. The heterogeneity, which leaded to high I^2 values for our incorporated results for operative time, kyphotic angle, ABHL, SI and cobb angle, might be interpreted by the research design, inadequate baseline comparisons, and the distinct result measurements. Furthermore, the pooled literatures were mostly released in English and this may result in a cultural, language, and/or publication bias. Therefore, more randomized controlled trials with high quality are still required in the future.

Conclusion

The main results of this review indicated that the final outcomes of radiographic indexes in regard to ABHL, cobb angle and SI were better in the LS fixation group than those of SS fixation group. The implant failure is less in the LS fixation group than that of SS fixation group. However, LS fixation prolonged the duration of operation significantly. Furthermore, clinical outcomes suggested that there was no difference between the SS and LS fixation. Hence it is difficult to recommend one modality over the other, the choice of the appropriate method have to be made cautiously and on a individualized basis. It is significant that more high-quality, randomized controlled trials be designed to direct the selection of the surgical modality in patients with thoracolumbar burst fractures.

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Disclosure of conflict of interest

None.

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References

[1] Suzuki T, Abe E, Miyakoshi N, Murai H, Kobayashi T, Abe T, Kikuchi K and Shimada Y. Anterior decompression and shortening reconstruction with a titanium mesh cage through a posterior approach alone for the treatment of lumbar burst fractures. Asian Spine J 2012; 6: 123-130.

[2] Dai LY, Jiang LS and Jiang SD. Conservative treatment of thoracolumbar burst fractures: a long-term follow-up results with special reference to the load sharing classification. Spine (Phila Pa 1976) 2008; 33: 2536-2544.

[3] Post RB, van der Sluis CK, Leferink VJ and Ten DH. Long-term functional outcome after type A3 spinal fractures: operative versus non-operative treatment. Acta Orthop Belg 2009; 75: 389-395.

[4] Thomas KC, Bailey CS, Dvorak MF, Kwon B and Fisher C. Comparison of operative and nonoperative treatment for thoracolumbar burst fractures in patients without neurological deficit: a systematic review. J Neurosurg Spine 2006; 4: 351-358.

[5] Heary RF, Salas S, Bono CM and Kumar S. Complication avoidance: thoracolumbar and lumbar burst fractures. Neurosurg Clin N Am 2006; 17: 377-388.

[6] La Rosa G, Conti A, Cardali S, Cacciola F and Tomasello F. Does early decompression improve neurological outcome of spinal cord injured patients? Appraisal of the literature using a meta-analytical approach. Spinal Cord 2004; 42: 503-512.

[7] Tezeren G and Kuru I. Posterior fixation of thoracolumbar burst fracture: short-segment pedicle fixation versus long-segment instrumentation. J Spinal Disord Tech 2005; 18: 485-488.

[8] Altay M, Ozkurt B, Aktekin CN, Ozturk AM, Dogan O and Tabak AY. Treatment of unstable thoracolumbar junction burst fractures with short- or long-segment posterior fixation in magerl type a fractures. Eur Spine J 2007; 16: 1145-1155.

[9] Lee S, Pandher D, Yoon K, Lee S and Oh KJ. The effect of postoperative immobilization on short-segment fixation without bone grafting for unstable fractures of thoracolumbar spine. Indian J Orthop 2009; 43: 197-204.

[10] Kim HS, Lee SY, Nanda A, Kim JY, Park JO, Moon SH, Lee HM, Kim HJ, Wei H and Moon ES. Comparison of surgical outcomes in thoracolumbar fractures operated with posterior constructs having varying fixation length with selective anterior fusion. Yonsei Med J 2009; 50: 546-554.

[11] Sapkas G, Kateros K, Papadakis SA, Brilakis E, Macheras G and Katonis P. Treatment of unstable thoracolumbar burst fractures by indirect reduction and posterior stabilization: short-segment versus long-segment stabilization. Open Orthop J 2010; 4: 7-13.

[12] Moon MS, Choi WT, Sun DH, Chae JW, Ryu JS, Chang H and Lin JF. Instrumented ligamentotaxis and stabilization of compression and burst fractures of dorsolumbar and mid-lumbar spines. Indian J Orthop 2007; 41: 346-353.

[13] Tabak AY, Gunay MC, Altay M and Turker HB. [Effects of short- and long-segment posterior instrumentation on spinal canal remodeling in thoracolumbar vertebra burst fractures]. Ulus Travma Acil Cerrahi Derg 2011; 17: 141-148.

[14] McLain RF. The biomechanics of long versus short fixation for thoracolumbar spine fractures. Spine (Phila Pa 1976) 2006; 31: S70-S79, S104.

[15] Akbarnia BA, Crandall DG, Burkus K and Matthews T. Use of long rods and a short arthrodesis for burst fractures of the thoracolumbar spine. A long-term follow-up study. J Bone Joint Surg Am 1994; 76: 1629-1635.

[16] Bastian L, Lange U, Knop C, Tusch G and Blauth M. Evaluation of the mobility of adjacent segments after posterior thoracolumbar fixation: a biomechanical study. Eur Spine J 2001; 10: 295-300.

[17] Koller H, Acosta F, Hempfing A, Rohrmuller D, Tauber M, Lederer S, Resch H, Zenner J, Klampfer H, Schwaiger R, Bogner R and Hitzl W. Long-term investigation of nonsurgical treatment for thoracolumbar and lumbar burst fractures: an outcome analysis in sight of spinopelvic balance. Eur Spine J 2008; 17: 1073-1095.

[18] Dick W, Kluger P, Magerl F, Woersdorfer O and Zach G. A new device for internal fixation of thoracolumbar and lumbar spine fractures: the 'fixateur interne'. Paraplegia 1985; 23: 225-232.

[19] Moon MS, Choi WT, Moon YW, Kim YS and Moon JL. Stabilisation of fractured thoracic and lumbar spine with Cotrel-Dubousset instrument. J Orthop Surg (Hong Kong) 2003; 11: 59-66.

[20] Akbarnia BA, Crandall DG, Burkus K and Matthews T. Use of long rods and a short arthrodesis for burst fractures of the thoracolumbar spine. A long-term follow-up study. J Bone Joint Surg Am 1994; 76: 1629-1635.
[21] Schroeder GD, Kepler CK, Koerner JD, Oner FC, Fehlings MG, Aarabi B, Schnake KJ, Rajasekaran S, Kandziora F, Vialle LR and Vaccaro AR. Can a thoracolumbar injury severity score be uniformly applied from T1 to L5 or are modifications necessary? Global Spine J 2015; 5: 339-345.
[22] Dai J, Lin H, Niu S, Wu X, Wu Y and Zhang H. Correlation of bone fragments reposition and related parameters in thoracolumbar burst fractures patients. Int J Clin Exp Med 2015; 8: 11125-11131.
[23] Verlaan JJ, Diekerhof CH, Buskens E, van der Tweel I, Verbout AJ, Dhert WJ and Oner FC. Surgical treatment of traumatic fractures of the thoracic and lumbar spine: a systematic review of the literature on techniques, complications, and outcome. Spine (Phila Pa 1976) 2004; 29: 803-814.
[24] Panchal RR, Matheis EA, Gudipally M, Hussain MM, Kim KD and Bucklen BS. Is lateral stabilization enough in thoracolumbar burst fracture reconstruction? A biomechanical investigation. Spine J 2015; 15: 2247-2253.
[25] Guven O, Kocaoglu B, Bezer M, Aydin N and Nalbantoglu U. The use of screw at the fracture level in the treatment of thoracolumbar burst fractures. J Spinal Disord Tech 2009; 22: 417-421.
[26] Stahl S, Vida D, Meisner C, Lotter O, Rothenberger J, Schaller H and Stahl AS. Systematic review and meta-analysis on the work-related etiology of de Quervain's tenosynovitis: a critical appraisal of its recognition as an occupational disease. Plast Reconstr Surg 2013; 132: 1479-91.
[27] Dimar JN, Wilde PH, Glassman SD, Puno RM and Johnson JR. Thoracolumbar burst fractures treated with combined anterior and posterior surgery. Am J Orthop (Belle Mead NJ) 1996; 25: 159-165.
[28] Wang L, Li J, Wang H, Yang Q, Lv D, Zhang W, Tang K, Shang L, Jiang C, Wu C, Ma K, Wang B, Liu Y, Zhang R, Shang X, Kou D, Jia X, Yang X, Tang Y, Zhang M, Wang P, Xu Y and Wang S. Posterior short segment pedicle screw fixation and TLIF for the treatment of unstable thoracolumbar/lumbar fracture. BMC Musculoskelet Disord 2014; 15: 40.
[29] Parker JW, Lane JR, Karaikovic EE and Gaines RW. Successful short-segment instrumentation and fusion for thoracolumbar spine fractures: a consecutive 41/2-year series. Spine (Phila Pa 1976) 2000; 25: 1157-1170.
[30] Khare S and Sharma V. Surgical outcome of posterior short segment trans-pedicle screw fixation for thoracolumbar fractures. J Orthop 2013; 10: 162-167.
[31] Audige L, Cornelius CP, Di Ieva A and Prein J. The first AO classification system for fractures of the craniomaxillofacial skeleton: rationale, methodological background, developmental process, and objectives. Craniomaxillofac Trauma Reconstr 2014; 7: S6-S14.
[32] Daniaux H, Seykora P, Genelin A, Lang T and Kathrein A. Application of posterior plating and modifications in thoracolumbar spine injuries. Indication, techniques, and results. Spine (Phila Pa 1976) 1991; 16: S125-S133.
[33] Knop C, Fabian HF, Bastian L, Rosenthal H, Lange U, Zdichavsky M and Blauth M. Fate of the transpedicular intervertebral bone graft after posterior stabilisation of thoracolumbar fractures. Eur Spine J 2002; 11: 251-257.
[34] Leferink V, Zimmerman K, Veldhuis E, Ten Vergert E and Ten Duis H. Thoracolumbar spinal fractures: radiological results of transpedicular fixation combined with transpedicular cancellous bone graft and posterior fusion in 183 patients. Eur Spine J 2001; 10: 517-523.
[35] Hegde A, Babu R and Shetty A. Management of unstable thoraco-lumbar fractures with pedicular screw instrumentation: a series of 30 cases. J Clin Diagn Res 2013; 7: 2563-2566.
[36] Heini PF. Comment on "Transpedicle body augmenter in painful osteoporotic compression fractures" (Kung-Chia Li, Anna F.-Y. Li, Ching-Hsiang Hsieh, Hsiang-Ho Chen). Eur Spine J 2007; 16: 599-600.
[37] Aebli N, Timm K, Patrick M and Krebs J. Short-segment posterior instrumentation combined with anterior spondylodesis using an autologous rib graft in thoracolumbar burst fractures. Acta Orthop 2014; 85: 84-90.
[38] Hegde A. Management of unstable thoracolumbar fractures with pedicular screw instrumentation: a series of 30 cases. J Clin Diagn Res 2013; 7: 2563-6.
[39] Lee G, Lee J, Hur H, Jang J, Kim T and Kim S. Comparison of clinical and radiologic results between expandable cages and titanium mesh cages for thoracolumbar burst fracture. J Korean Neurosurg S 2014; 55: 142.
[40] Wang H, Li C, Liu T, Zhao WD and Zhou Y. Biomechanical efficacy of monoaxial or polyaxial pedicle screw and additional screw insertion at the level of fracture, in lumbar burst fracture: an experimental study. Indian J Orthop 2012; 46: 395-401.

[41] Hartensuer R, Gehweiler D, Schulze M, Matuszewski L, Raschke MJ and Vordemvenne T. Biomechanical evaluation of combined short segment fixation and augmentation of incomplete osteoporotic burst fractures. BMC Musculoskelet Disord 2013; 14: 360.
[42] Oner FC, Dhert WJ and Verlaan JJ. Less invasive anterior column reconstruction in thoracolumbar fractures. Injury 2005; 36 Suppl 2: B82-B89.
[43] Canbek U, Karapinar L, Imerci A, Akgun U, Kumbaraci M and Incesu M. Posterior fixation of thoracolumbar burst fractures: is it possible to protect one segment in the lumbar region? Eur J Orthop Surg Traumatol 2014; 24: 459-465.