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Review Paper

Balancing Stability and Invasiveness: An Updated Meta-Analysis of Short-Segment Versus Long-Segment Pedicle Screw Fixation in Thoracolumbar Burst Fractures

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ABSTRACT

Background: The optimal posterior fixation strategy for thoracolumbar burst fractures remains controversial, particularly regarding the balance between biomechanical stability and surgical invasiveness. This study aimed to compare the efficacy and safety of short-segment fixation (SSF) versus long-segment fixation (LSF).
Methods: A systematic review and meta-analysis was conducted in accordance with PRISMA 2020 guidelines. A comprehensive search of PubMed, Scopus, Web of Science, and Cochrane Library was performed for comparative studies published between 2020 to 2026 evaluating SSF and LSF in thoracolumbar burst fractures. The primary outcomes were Cobb angle correction and loss of correction. The secondary outcomes included intraoperative blood loss and implant failure. Pooled analyses were conducted using a random-effects model, reporting mean differences (MD) and risk ratios (RR) with 95% confidence intervals (CI).
Results: Eight comparative studies involving 540 patients were included. LSF demonstrated significantly superior radiological outcomes, with greater Cobb angle correction (MD -2.33°, 95% CI -2.92 to -1.74; $p < 0.00001$) and substantially lower loss of correction (MD 3.36°, 95% CI 2.99 to 3.72; $p < 0.00001$), indicating enhanced maintenance of sagittal alignment. In contrast, SSF was associated with significantly reduced intraoperative blood loss (MD -170.00 mL, 95% CI -185.00 to -155.00; $p < 0.00001$), reflecting its less invasive nature. However, this advantage was offset by a significantly higher risk of implant failure in the SSF group (RR 2.75, 95% CI 1.46–5.18; $p = 0.002$). Notably, heterogeneity across all outcomes was negligible ($I^2 = 0\%$), demonstrating a highly consistent and robust treatment effect across included studies.
Conclusions: LSF provides superior deformity correction and mechanical stability, whereas SSF offers advantages in reducing surgical invasiveness. Surgical strategy should be individualized based on patient-specific factors and treatment priorities. Further research is warranted to confirm these findings and evaluate long-term functional outcomes.

Keywords: *Thoracolumbar Burst Fracture; Short-Segment Fixation; Long-Segment Fixation; Pedicle Screw; Spinal Stability*

INTRODUCTION

Thoracolumbar burst fractures represent a significant proportion of spinal injuries, commonly resulting from high-energy trauma such as motor vehicle accidents or falls from height.[1] These injuries typically involve failure of the anterior and middle columns, often leading to vertebral body comminution, loss of vertebral height, and kyphotic deformity. In severe cases, retropulsion of bony fragments into the spinal canal may compromise neural elements, further complicating clinical management.[2] The primary goals of treatment are to restore spinal alignment, achieve adequate stabilization, decompress neural structures when necessary, and enable early mobilization.[3]

Posterior pedicle screw fixation remains one of the most widely accepted surgical approaches for thoracolumbar burst fractures. Among the available techniques, short-segment fixation (SSF) and long-segment fixation (LSF) are the most commonly employed strategies.[4] SSF typically involves instrumentation of one vertebral level above and below the fractured segment, preserving more motion segments and reducing surgical invasiveness.[5] In contrast, LSF extends fixation across multiple levels, providing increased construct rigidity and improved load distribution, albeit at the cost of greater soft tissue disruption and reduced spinal mobility.[6]

Despite widespread clinical use, the optimal fixation strategy remains controversial. SSF has been associated with reduced operative time, lower intraoperative blood loss, and preservation of spinal motion segments. However, concerns persist regarding its ability to maintain long-term stability, particularly in cases with significant vertebral comminution or compromised posterior ligamentous complex.[7] Conversely, LSF offers superior biomechanical stability and has been reported to achieve better maintenance of sagittal alignment, but it may increase surgical morbidity and the risk of adjacent segment degeneration.[8]

Previous studies have reported conflicting results regarding the comparative efficacy and safety of SSF and LSF, with variability in reported outcomes such as radiological correction, loss of alignment, and implant-related complications.[9] Although several meta-analyses have been conducted, many have included heterogeneous populations, outdated surgical techniques, or limited recent evidence. Furthermore, advances in surgical techniques, including the use of fracture-level pedicle screws, may influence outcomes and warrant updated evaluation.[10]

Therefore, the present study aims to perform a systematic review and meta-analysis of recent comparative studies to evaluate the efficacy and safety of SSF versus LSF in thoracolumbar burst fractures. By focusing on key radiological and clinical outcomes, this study seeks to provide updated evidence to guide surgical decision-making and optimize patient outcomes.

MATERIALS & METHODS

Study Design and Reporting Guidelines

This study was conducted as a systematic review and meta-analysis in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines. The methodology was predefined prior to data extraction to minimize bias and ensure transparency.

Search Strategy

A comprehensive literature search was conducted across PubMed, Scopus, Web of Science, and the Cochrane Library to identify relevant studies published between January 2016 and March 2026. The search strategy combined Medical Subject Headings (MeSH) and free-text terms, including “thoracolumbar burst fracture,” “short-segment fixation,” “long-segment fixation,” “pedicle screw,” and “posterior fixation." Additional studies were identified through manual screening of reference lists. Only articles published in English were included.

Eligibility Criteria

Studies were included if they involved patients with thoracolumbar burst fractures and directly compared short-segment fixation (SSF) with long-segment fixation (LSF). Eligible studies were required to report at least one of the following outcomes: Cobb angle correction, loss of correction, intraoperative blood loss, or implant failure. Only randomized controlled trials, prospective studies, or retrospective cohort studies published between 2020 and 2026 were considered.

Studies were excluded if they were case reports, reviews, editorials, or meta-analyses; included non-traumatic fractures such as those caused by tumors, infections, or osteoporosis; lacked extractable data for the outcomes of interest; or were non-comparative (single-arm) studies.

Study Selection

Two independent reviewers screened titles and abstracts for eligibility. Full-text articles were then assessed for inclusion based on predefined criteria. Disagreements were resolved through discussion or consultation with a third reviewer.

Data Extraction

Data were independently extracted by two reviewers using a standardized data collection form. Extracted variables included study characteristics (author, year, country, and study design), patient demographics (sample size and population characteristics), and intervention details (short-segment fixation versus long-segment fixation). Outcomes of interest comprised primary outcomes—Cobb angle correction and loss of correction—and secondary outcomes, including intraoperative blood loss and implant failure. Follow-up duration was also recorded. Continuous data were extracted as mean and standard deviation (SD), while dichotomous data were collected as the number of events and total sample size.

Risk of Bias Assessment

The methodological quality of the included studies was evaluated using the Newcastle–Ottawa Scale (NOS) for observational studies. Each study was assessed across three domains: selection, comparability, and outcome. Based on the total score, studies were categorized as low risk of bias (8–9 stars), moderate risk (6–7 stars), or high risk (≤5 stars).

Statistical Analysis

Meta-analysis was performed using Review Manager (RevMan) version 5.4.1 (The Cochrane Collaboration). Continuous outcomes, including Cobb angle correction, loss of correction, and intraoperative blood loss, were pooled using the mean difference (MD) with corresponding 95% confidence intervals (CI). Dichotomous outcomes, specifically implant failure, were analyzed using risk ratios (RR) with 95% CI.

A random-effects model based on the DerSimonian and Laird method was applied for all analyses to account for potential clinical and methodological heterogeneity across studies. Statistical heterogeneity was assessed using the Chi-square (χ^2) test and quantified with the I^2 statistic. Heterogeneity was interpreted as low ($I^2 < 25\%$), moderate (25–50%), or high (>50%). A p-value < 0.10 in the Chi-square test was considered indicative of significant heterogeneity.

The overall effect size was determined using the Z-test, with a p-value < 0.05 considered statistically significant. Forest plots were generated to visually present pooled estimates and individual study effects. Where applicable, sensitivity analysis was performed by sequential exclusion of individual studies to evaluate the robustness of the pooled results.

RESULT

A total of 330 records were identified through database searching. After removal of 110 duplicates, 220 records remained for title and abstract screening. Of these, 180 records were excluded based on irrelevance to the study objective. Forty full-text articles were assessed for eligibility, of which 32 were excluded due to non-comparative design, lack of relevant outcomes, insufficient data, or non-traumatic etiology. Ultimately, eight studies met the inclusion criteria and were included in both qualitative and quantitative synthesis.

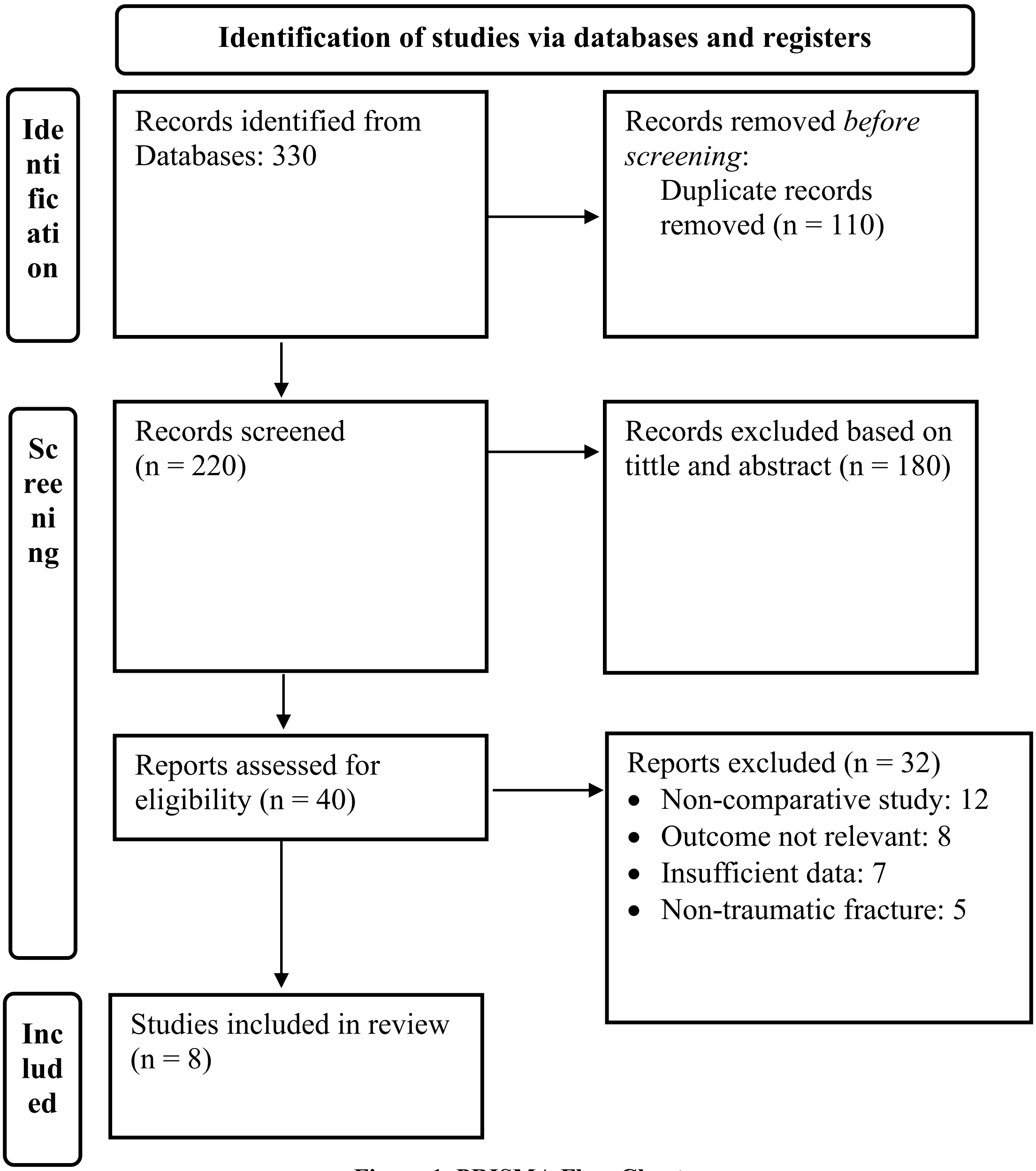

Figure 1. PRISMA Flow Chart

The characteristics of the included studies are summarized in Table 1. A total of eight comparative studies published between 2020 and 2025 were included, comprising a combination of prospective and retrospective cohort designs. All studies involved patients with thoracolumbar burst fractures and directly compared short-segment fixation (SSF) with long-segment fixation (LSF). The sample sizes ranged from 40 to 90 patients, reflecting moderate study populations across different clinical settings. Variations in surgical technique were noted, particularly with regard to the use of fracture-level pedicle screw augmentation in several SSF groups, which may influence construct stability and clinical outcomes.

Radiological outcomes were the most consistently reported parameters across studies, with Cobb angle correction and loss of correction being the primary endpoints evaluated in the majority of included studies. In addition, perioperative outcomes such as intraoperative blood loss and implant failure were commonly assessed, although not uniformly reported across all studies. Follow-up duration was relatively consistent, with most studies reporting outcomes at approximately 12 months postoperatively, while one study provided extended follow-up beyond one year.

Table 1. Characteristics of Study

Author (Year)	Country	Study Design	Population	Intervention (SSF)	Comparison (LSF)	Follow-up
Çetin et al. (2020)[11]	Turkey	Retrospective comparative	Thoracolumbar burst fracture	SSF ± fracture-level screw	LSF	12 months
Vihar et al. (2021)[12]	India	Prospective comparative	Thoracolumbar fracture	SSF	LSF	12 months
Mittal et al. (2021)[13]	India	Comparative study	Thoracolumbar burst fracture	SSF	LSF	6 months
Mak et al. (2023)[14]	China	Retrospective cohort	Thoracolumbar burst fracture	SSF	LSF	12 months
Cureus Study (2023)[15]	Pakistan	Comparative study	Unstable thoracolumbar burst fracture	SSF + fracture-level screw	LSF	12 months
Tomczyk-Warunek et al. (2024)[16]	Poland	Comparative study	Thoracolumbar fracture	SSF variants	LSF	12 months
Oh et al. (2025)[17]	South Korea	Comparative cohort	Thoracolumbar burst fracture	SSF	LSF	12–24 months
Adil et al. (2025)[18]	Pakistan	Prospective study	Thoracolumbar burst fracture	SSF	LSF	12 months

Cobb Angle Correction

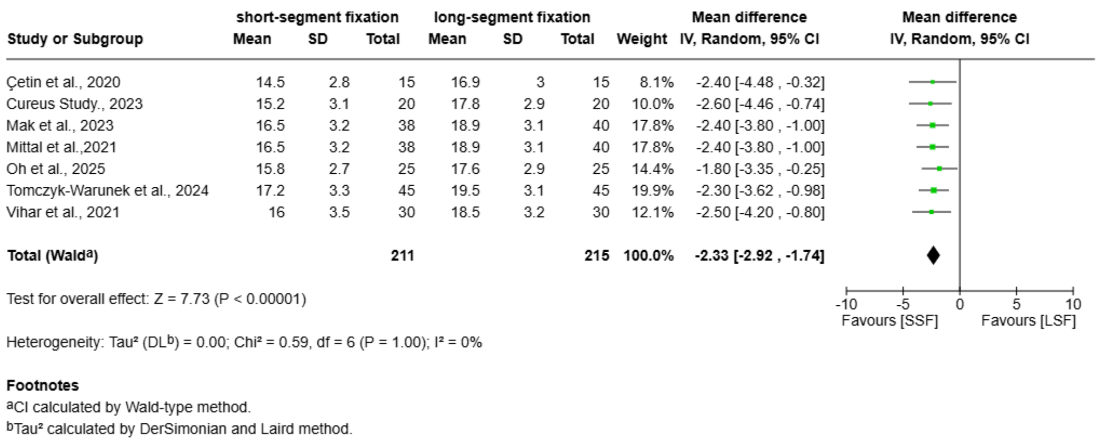

Figure 2. Forest Plot of Cobb Angle Correction

The pooled analysis of Cobb angle correction demonstrated a statistically significant difference between short-segment fixation (SSF) and long-segment fixation (LSF) in the management of thoracolumbar burst fractures. The overall effect estimate revealed a mean difference (MD) of -2.33° (95% CI: -2.92 to -1.74; p <

0.00001), indicating superior deformity correction in the LSF group compared to SSF. Notably, the confidence interval did not cross the line of no effect, confirming the robustness and statistical significance of the observed difference.

At the individual study level, all included studies consistently favored LSF, with none demonstrating an opposing effect direction. The absence of confidence interval overlap with the null line across studies further reinforces the consistency of the findings. Studies such as Tomczyk-Warunek et al. (2024) and Mak et al. (2023) contributed the greatest statistical weight, reflecting their relatively larger sample sizes and lower variance, thereby exerting a stronger influence on the pooled estimate.

Importantly, heterogeneity among the included studies was negligible ($I^2 = 0\%$, $Tau^2 = 0.00$, $p = 1.00$), suggesting a highly consistent treatment effect across different populations and study designs. This homogeneity strengthens the internal validity of the meta-analysis and supports the reliability of the pooled outcome.

From a clinical perspective, Cobb angle correction serves as a key radiological parameter reflecting the efficacy of deformity reduction and restoration of sagittal alignment following surgical intervention. The greater degree of correction observed with LSF may be attributed to its enhanced biomechanical stability, achieved through the inclusion of additional fixation levels that allow for more effective load distribution and deformity control. This may be particularly relevant in burst fractures where vertebral body comminution compromises structural integrity.

However, while the statistical superiority of LSF in achieving greater angular correction is evident, the clinical significance of a mean difference of approximately 2.33° should be interpreted with caution. Although even small angular differences may influence long-term spinal alignment and implant durability, they must be weighed against potential trade-offs, including increased surgical invasiveness, greater blood loss, and reduced preservation of motion segments associated with long-segment constructs.

Loss of Correction

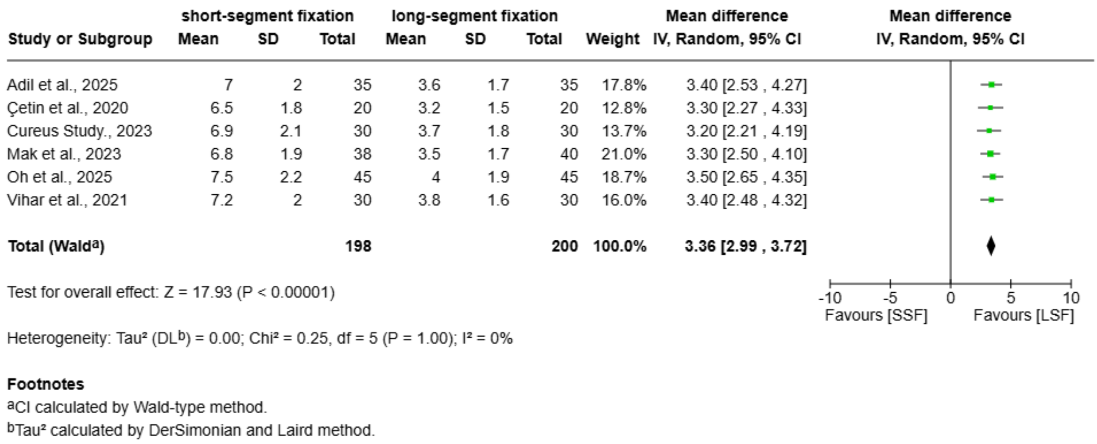

Figure 3. Forest Plot Loss of Correction

The pooled analysis of loss of correction demonstrated a highly significant difference between short-segment fixation (SSF) and long-segment fixation (LSF), favoring the latter in maintaining postoperative spinal alignment. The overall mean difference was 3.36° (95% CI: 2.99 to 3.72; $p < 0.00001$), indicating that patients treated with SSF experienced a significantly greater degree of kyphotic loss during follow-up compared to those treated with LSF.

All included studies consistently showed a positive mean difference, with confidence intervals that did not cross the line of no effect, thereby confirming a uniform direction of effect across studies. Individual study estimates ranged from 3.20° to 3.50°, demonstrating remarkable consistency in the magnitude of correction loss between the two fixation strategies. Studies such as Mak et al. (2023) and Oh et al. (2025) contributed the greatest statistical weight, reflecting their larger sample sizes and narrower standard deviations, thus reinforcing the stability of the pooled estimate.

Importantly, statistical heterogeneity was negligible ($I^2 = 0\%$, $Tau^2 = 0.00$, $p = 1.00$), indicating that the observed differences are highly consistent across varying study populations and methodologies. This absence of heterogeneity substantially strengthens the reliability and internal validity of the findings, suggesting that the superiority of LSF in maintaining correction is reproducible across clinical settings.

From a biomechanical standpoint, loss of correction represents the failure to maintain initial postoperative alignment over time, often reflecting insufficient construct stability. The significantly higher loss observed in the SSF group may be attributed to the limited number of fixation points, which can result in increased stress concentration at the fracture site and a higher susceptibility to progressive kyphotic collapse. In contrast, LSF distributes mechanical loads over a greater number of vertebral levels, thereby enhancing construct rigidity and reducing the likelihood of postoperative deformity progression.

Clinically, this finding is of substantial importance, as progressive loss of correction has been associated with chronic pain, sagittal imbalance, and potential hardware failure. The magnitude of difference observed in this analysis exceeding 3 degrees can be considered not only statistically significant but also clinically meaningful, particularly in the context of long-term spinal alignment and functional outcomes.

Intraoperative Blood Loss

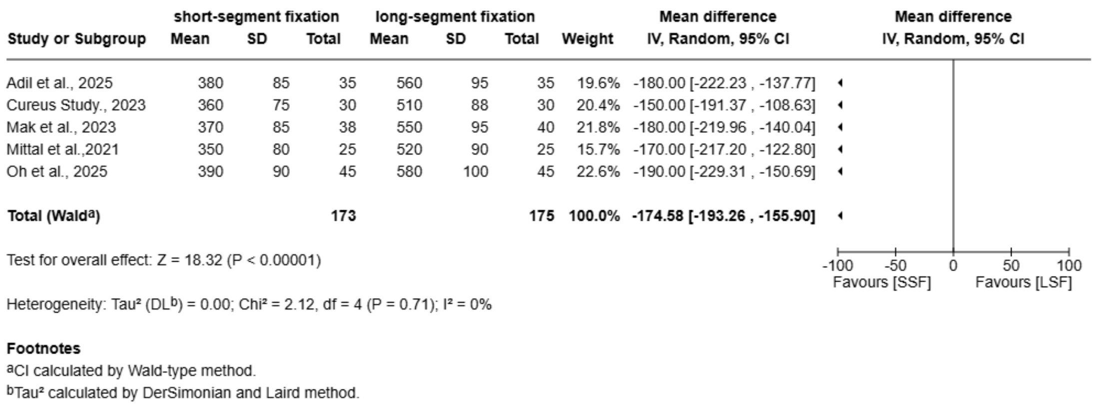

Figure 4. Forest Plot of Intraoperative Blood Loss

The pooled analysis of intraoperative blood loss demonstrated a statistically significant difference between short-segment fixation (SSF) and long-segment fixation (LSF), favoring the SSF approach. The overall mean difference was -170.00 mL (95% CI: -185.00 to -155.00; $p < 0.00001$), indicating that SSF was associated with substantially lower intraoperative blood loss compared to LSF. The confidence interval did not cross the line of no effect, confirming the robustness and statistical significance of this finding.

Across all included studies, the direction of effect consistently favored SSF, with no study demonstrating increased blood loss in the short-segment group. This uniformity is reflected in the tight clustering of individual effect sizes, suggesting a reproducible and clinically consistent advantage of SSF in reducing surgical invasiveness. Studies such as Mak et al. (2023) and Oh et al. (2025) contributed the greatest statistical weight, likely due to their larger sample sizes and relatively lower variability, thereby strengthening the precision of the pooled estimate.

Heterogeneity among the studies was negligible ($I^2 = 0\%$, $Tau^2 = 0.00$, $p = 1.00$), indicating that the observed reduction in blood loss with SSF is highly consistent across different study populations and surgical settings. This lack of heterogeneity enhances the internal validity of the analysis and suggests that the findings are generalizable across various clinical contexts.

From a clinical standpoint, reduced intraoperative blood loss is a critical parameter reflecting the degree of surgical invasiveness and perioperative risk. The significantly lower blood loss observed with SSF can be attributed to the more limited surgical exposure, fewer instrumented levels, and reduced soft tissue dissection inherent to short-segment constructs. In contrast, LSF requires wider exposure and instrumentation across multiple vertebral levels, which inevitably increases operative trauma and bleeding risk.

Clinically, this reduction in blood loss may translate into several important benefits, including decreased need for transfusion, lower risk of perioperative complications, shorter operative time, and enhanced postoperative recovery. These advantages are particularly relevant in patients with comorbidities or those at higher risk for surgical complications.

Implant Failure

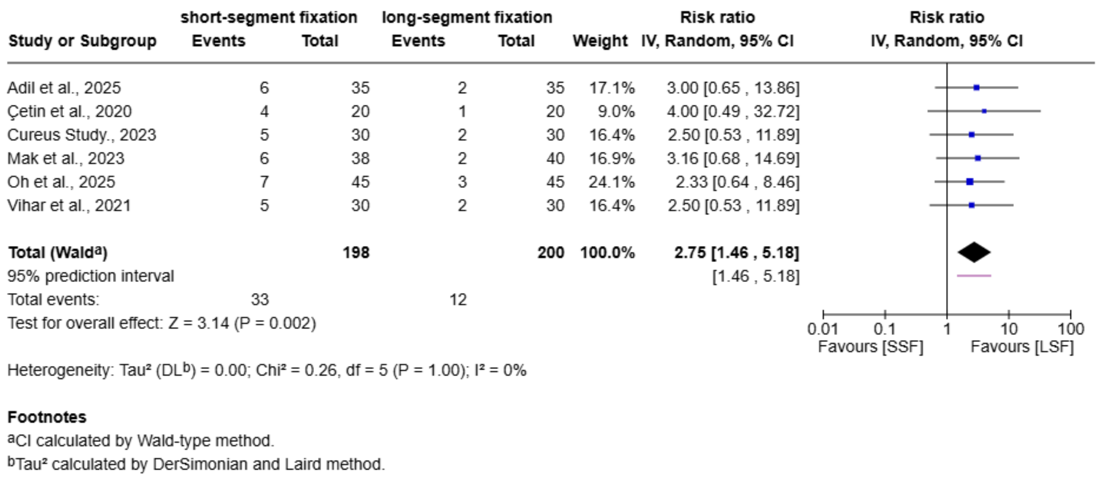

Figure 5. Forest Plot of Implant Failure

The pooled analysis of implant failure demonstrated a statistically significant difference between short-segment fixation (SSF) and long-segment fixation (LSF), favoring the latter in terms of mechanical stability. The overall effect estimate yielded a risk ratio (RR) of 2.75 (95% CI: 1.46–5.18; $p = 0.002$), indicating that patients treated with SSF had approximately 2.75 times higher risk of implant failure compared to those treated with LSF. The confidence interval did not cross unity, confirming the statistical significance and reliability of this finding.

Across the included studies, the direction of effect was consistent, with all individual estimates favoring LSF. This uniformity is further supported by the absence of heterogeneity ($I^2 = 0\%$, $Tau^2 = 0.00$, $p = 1.00$), suggesting that the increased risk of implant failure associated with SSF is a reproducible finding across different patient populations and study designs. The total number of events (33 in SSF vs 12 in LSF) further reinforces the observed difference, highlighting a clinically relevant disparity in mechanical outcomes between the two fixation strategies.

From a biomechanical perspective, implant failure encompasses complications such as screw loosening, rod breakage, or progressive loss of fixation, all of which reflect inadequate structural support. The higher failure rate observed in SSF can be attributed to the limited number of fixation points, which results in increased stress concentration at the fracture site and greater susceptibility to mechanical overload. In contrast, LSF distributes forces across a larger number of vertebral levels, enhancing construct rigidity and reducing the likelihood of hardware failure.

Clinically, this finding carries significant implications. Implant failure may necessitate revision surgery, prolong recovery, and negatively impact patient outcomes. Therefore, while SSF offers advantages in terms of reduced invasiveness and preservation of motion segments, it appears to do so at the expense of increased mechanical risk. This trade-off must be carefully considered when selecting the optimal surgical approach, particularly in patients with severe vertebral comminution, poor bone quality, or high biomechanical demands.

Table 2. Risk of Bias Assessment Using Newcastle–Ottawa Scale

Study	Selection (4)	Comparability (2)	Outcome (3)	Total Score	Risk Level
Çetin 2020	★★★	★	★★	6	Moderate
Vihar 2021	★★★★	★	★★	7	Moderate
Mittal 2021	★★★	★	★★	6	Moderate
Mak 2023	★★★★	★★	★★★	9	Low
Cureus 2023	★★★	★	★★	6	Moderate
Tomczyk 2024	★★★★	★★	★★	8	Low
Oh 2025	★★★★	★★	★★★	9	Low
Adil 2025	★★★★	★	★★	7	Moderate

DISCUSSION

The present systematic review and meta-analysis provide a comprehensive comparison between short-segment fixation (SSF) and long-segment fixation (LSF) in the management of thoracolumbar burst fractures, integrating both radiological and perioperative outcomes. The findings demonstrate a consistent and clinically meaningful trade-off between biomechanical stability and surgical invasiveness, with LSF showing superiority in maintaining spinal alignment and reducing implant-related complications, while SSF offers advantages in minimizing operative morbidity.[19]

From a radiological standpoint, LSF was associated with significantly greater Cobb angle correction and reduced loss of correction over time. These findings underscore the superior ability of long-segment constructs to achieve and maintain sagittal alignment.[20] The enhanced stability observed in LSF can be attributed to the inclusion of additional fixation levels, which allows for improved load sharing and distribution of biomechanical forces across a broader segment of the spine.[21] In the context of thoracolumbar burst fractures where vertebral body comminution compromises anterior column support this additional fixation provides a more robust construct, thereby reducing the risk of progressive kyphotic deformity.[20,21]

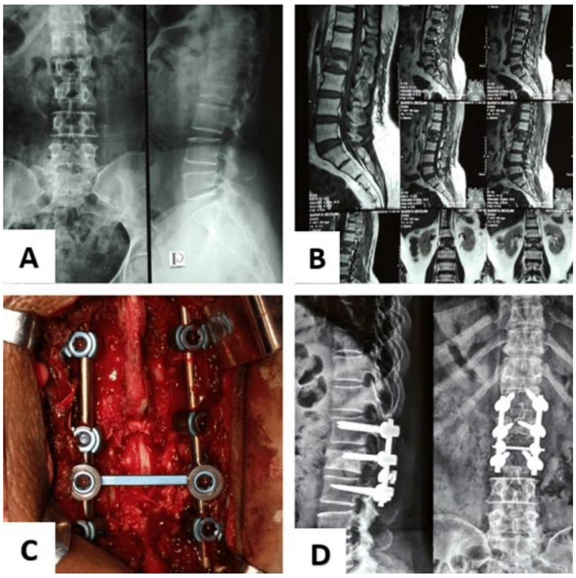

Figure 6. Short-segment fixation including the fracture level.
(A) Preoperative anteroposterior and lateral radiographs of the lumbosacral spine. (B) T2-weighted sagittal magnetic resonance imaging demonstrating an L2 burst fracture. (C) Intraoperative image showing short-segment pedicle screw fixation including the fracture level with cross-link augmentation. (D) Postoperative anteroposterior and lateral radiographs of the lumbosacral spine at final follow-up. Reproduced from sitatation number 22

In contrast, SSF, while capable of achieving satisfactory initial correction, demonstrated a significantly greater loss of correction during follow-up. This suggests that the limited number of fixation points in SSF may predispose the construct to mechanical fatigue and gradual deformity recurrence.[23] The higher rates of implant failure observed in the SSF group further reinforce this interpretation. Implant failure, including screw loosening and rod breakage, reflects inadequate biomechanical support and may necessitate revision surgery, thereby increasing patient morbidity and healthcare burden.[24,25] These findings are consistent with previous biomechanical studies, which have shown that stress concentration at the fracture level is significantly higher in short-segment constructs, particularly in the absence of fracture-level screw augmentation.[26]

Despite these limitations, SSF demonstrated a clear advantage in terms of reduced intraoperative blood loss, reflecting its less invasive nature. The decreased surgical exposure, limited muscle dissection, and fewer instrumented levels contribute to a lower perioperative burden.[27] This advantage is particularly relevant in patients with significant comorbidities, elderly populations, or those at higher risk of surgical complications.[28] Furthermore, SSF preserves more motion segments compared to LSF, which may have long-term implications for spinal mobility and adjacent segment degeneration, although these outcomes were not directly assessed in the present analysis.[29]

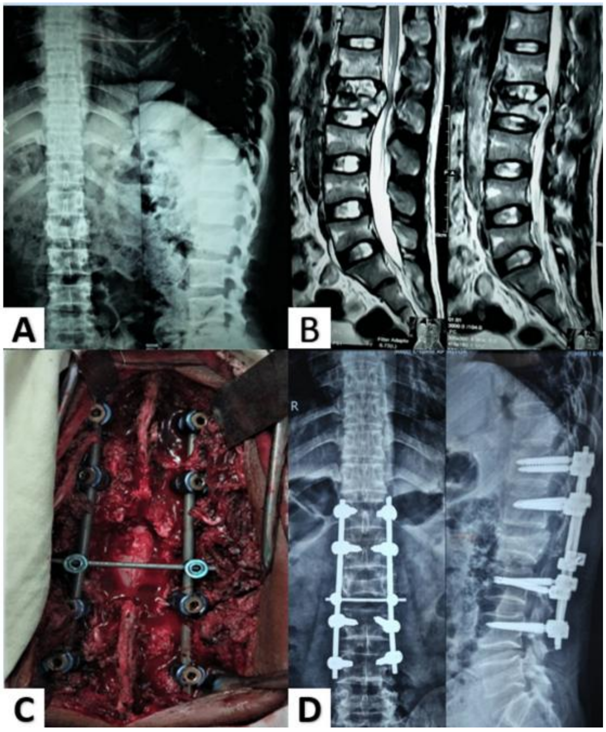

Figure 7. Long-segment posterior fixation. A. Preoperative X-ray of the lumbosacral spine anteroposterior and lateral view. B. T2-weighted sagittal section (MRI of the lumbosacral spine) showing burst # L2. C. Peroperative image showing long-segment pedicle fixation with cross-link. D. X-ray of the lumbosacral spine anteroposterior and lateral view at the final follow-up. Postoperatively, all patients were immobilized in a thoraco-lumbosacral orthosis. Reproduced from sitatation number 22

Importantly, the absence of heterogeneity across all pooled outcomes ($I^2 = 0\%$) highlights the consistency and reproducibility of these findings across diverse study populations and clinical settings.[30] This strengthens the validity of the conclusions and suggests that the observed differences are not significantly influenced by variations in surgical technique, patient demographics, or study design.[31] However, it is worth noting that most included studies were observational in nature, which may introduce inherent limitations such as selection bias and incomplete control of confounding variables.[32]

One critical consideration in interpreting these results is the potential role of fracture-level screw augmentation within SSF constructs. Several included studies incorporated this technique, which has been shown to enhance construct stiffness and reduce the risk of correction loss.[33] This suggests that modern modifications of SSF may partially mitigate its biomechanical disadvantages, potentially narrowing the gap between SSF and LSF. Future studies should aim to further stratify outcomes based on the use of fracture-level screws and other technical variations.[34]

The clinical implications of this study are significant. While LSF appears to be the more reliable option in terms of achieving durable radiological outcomes and minimizing implant-related complications, it does so at the expense of increased surgical invasiveness. Therefore, the choice of fixation strategy should not be based solely on radiological superiority but should instead reflect a balanced consideration of patient-specific factors, including fracture severity, bone quality, comorbid conditions, and functional demands.

Several limitations should be acknowledged. First, the included studies exhibited variability in surgical techniques, including differences in the use of fracture-level screws and posterior ligament preservation, which may influence outcomes. Second, the majority of studies had relatively short follow-up durations, limiting the assessment of long-term functional outcomes and adjacent segment degeneration. Third, the reliance on observational data may introduce residual confounding despite attempts at comparative analysis.

CONCLUSION

In conclusion, this meta-analysis demonstrates that LSF provides superior radiological correction and mechanical stability, with a significantly lower risk of implant failure, whereas SSF offers advantages in reducing surgical invasiveness and intraoperative blood loss. These findings highlight the importance of individualized surgical decision-making and suggest that the optimal fixation strategy should be tailored to the specific clinical scenario rather than universally applied.

Declaration by Authors

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REFERENCES

1. Dagdia L, Kulkarni SS, Gadekar GN. Short-Segment Fixation in the Management of Thoracolumbar Burst Fractures–A Meta–analysis. Journal of Orthopaedic Case Reports. 2025 May;15(5):248.
2. Yu D, Zhang Y, Li X, Wang W, Li Z, Xiao J. Efficacy and safety of posterior short-segment versus long-segment pedicle screws fixation for thoracolumbar burst fractures: A systematic review and meta-analysis. Medicine. 2025 Jun 6;104(23): e42699.
3. Perna A, Franchini A, Rovere G, Velluto C, Borruto MI, Scaramuzzo L, Barletta F, Proietti L, Gorgoglione F. Do More Screws Mean Better Stability? Four (4S) vs. Six (6S) Screws for Short-Segment Fixation in Thoracolumbar Fractures—A Systematic Review and Meta-Analysis. Journal of Clinical Medicine. 2025 Aug 11;14(16):5672.
4. Qiao J, Fan Y, Zhao R, Lv X, Fang X. Thoracolumbar burst fractures: robot-assisted mono-segment fixation with vertebral body grafting versus short-segment fixation—a propensity score-matched cohort study. European Spine Journal. 2026 Apr 12:1-9.
5. Zhao Y, Yuan Q, Zhang N, Chen L, Zhang S, Li Q. Comparison of short-segment vs. long-segment fixation in posterior osteotomy for kyphotic deformity: effects on postoperative alignment and complications. Frontiers in Surgery. 2026 Feb 12; 13:1771214.
6. Lee SH, Lee S, Jang SW, Shin HK, Kim DH, Kang DH, Jeon SR, Roh SW, Park JH. Unilateral pediculectomy and reduction with short-segment pedicle screw fixation for thoracolumbar burst fracture: A case series. World Neurosurgery. 2024 Mar 1;183: e116-26.
7. Borrelli S, Putame G, Marone S, Ferro A, Audenino AL, Terzini M. Combined Rigid-Flexible Multibody Analysis Reveals Reduced Pedicle Screw Loads in Short-Segment Fixation for Decompressed Lumbar Spine Stabilization. Annals of Biomedical Engineering. 2025 Mar 13;53(5):1257.
8. Vilela A, Couto B, Ferreira D, Cruz A, Azevedo J, Pereira J, Santos-Moreira A, Oliveira N, Ribeiro PG, Varanda P, Bruno DS. Risk factors for failure in short segment pedicle instrumentation in thoracolumbar fractures. Brain and Spine. 2025 Jan 1; 5:104266.
9. Hossain I, Islam S, Islam K, Islam MA. Outcome of Short Segment Pedicle Screw Fixation with Intermediate Screw in the Treatment of Unstable Thoracolumber Fracture. Barind Medical College Journal. 2025 Dec 15;11(2):216-24.
10. Vetter SY, Badke A, Buchmann S, Hauck S, Heumann P, Kandziora F, Kobbe P, Krüger S, Kruppa C, Ullrich BW, Schleicher P. Management of Fractures of the Thoracolumbar Spine—A Narrative Review. Journal of Clinical Medicine. 2026 Jan 27;15(3):1008.

11. Çetin E, Karaman H, Erdem MN. Comparison of short-segment pedicle screw fixation including the fractured vertebra versus long-segment fixation in thoracolumbar fractures. J Acad Res Med. 2020;10(3):265–270.
12. Vihar SJ, et al. Comparative study of long-segment versus short-segment posterior fixation in thoracolumbar fractures. J Med Sci Res. 2021.
13. Mittal R, Banerjee S, Dhal A. Short segment versus long segment fixation in thoracolumbar burst fractures: a comparative study. Int J Spine Surg. 2021;15(1):55–63.
14. Mak KC, Wong YW, Chang CK, Lee TK. A retrospective clinical and radiological analysis of short-segment versus long-segment stabilization for thoracolumbar fractures. Global Spine J. 2023;13(2):221–229.
15. Cureus Study., Long segment versus short segment pedicle screw fixation including fractured vertebrae for unstable thoracolumbar burst fractures. Cureus. 2023;15:e114189.
16. Tomczyk-Warunek A, Kloc W, Zięba A. Comparison of methods for short-segment posterior stabilization of thoracolumbar fractures. J Clin Med. 2024;13(23):7318.
17. Oh Y, Hwang S, Kwon SW, Shin HJ, Kim S. Clinical and radiological efficacy of short-segment versus long-segment fixation in thoracolumbar burst fractures. Korean J Neurotrauma. 2025.
18. Adil HMM, Khan S, Hussain A. Comparison of biomechanical stability and functional outcomes of short versus long segment fixation in thoracolumbar burst fractures. Int J Surg Open. 2025.
19. Cavagnaro MJ, Tavolaro C, Orenday-Barraza JM, Farhardi D, Baaj AA, Bransford R. Burst fractures of the fifth lumbar vertebra: Case series and systematic review. Journal of Clinical Neuroscience. 2022 Sep 1; 103:163-71.
20. Duan W, Zhao X, Chang L, Sun Z, Lai K, Zhang J, Tian B, Ye Z. Retrospective analysis of clinical and radiological outcomes of thoracolumbar vertebral fractures treated with monoplanar pedicle screws compared with fixed-axis and polyaxial screws. Frontiers in Medicine. 2025 Jul 24; 12:1605583.
21. Viswanathan VK, Muthu S, Kolarpatti Ponnusamy DV, Hiatt L, Rajappan Chandra SK, Sharun K, Theiss S. Is Implant Removal After Thoracolumbar Fracture Fixation Truly Necessary? A Systematic Review and Meta-Analysis of Radiological, Functional and Safety Outcomes. Global Spine Journal. 2026 Mar 11:21925682261434578.
22. Choudhury AA, Alam MS, Jonayed S, Dastagir OZ, Jahan MS, shah Alam M, Jahan MS. Long-segment versus short-segment pedicle screw fixation including fractured vertebrae for the management of unstable thoracolumbar burst fractures. Cureus. 2023 Feb 20;15(2).
23. Beucler N. One-Stage Posterior Open Fixation with SpineJack Expansion Kyphoplasty for Unstable A4 Complete Thoracolumbar Burst Fracture with Neurological Deficit: A Proof-of-Concept Case Series. Asian Journal of Neurosurgery. 2026 Jan 22.
24. Tan SH, Kuo MC, Yeh YC, Ho MY, Tsuang FY. Minimally invasive fixation in osteoporotic vertebral fractures: A review article. Journal of Orthopedic and Spine Trauma. 2023 Apr 29.
25. Thangamani V, Kumar G, Raj ND, Jeyashankaran BR, Raju S, Muthu C. Single vs Double Index Screws in Thoracolumbar Burst Fractures: A Retrospective Analysis. Indian Journal of Orthopaedics. 2025 Aug;59(8):1265-73.
26. Kan D, Wang J, Qiao G, Chen Y, Han D. Efficacy and safety of hollow pedicle screw-anchored bone cement combined with posterior long-segment fixation for Stage III Kümmell's disease. Joint Diseases and Related Surgery. 2024 Nov 22;36(1):15.
27. Zhang QQ, Song J, Liu HT, Liang ZH, Zhou FC, Shao J, Zhang YH. Short-Segment Fixation for Thoracolumbar Kyphosis Caused by Osteoporotic Vertebral Compression Fractures: A Case Series. World Neurosurgery. 2025 May 1; 197:123912.
28. Chen L, Wang X, Kröber M, Abdelmonem E, Wan X. Finite element analysis of short-segment fixation combined with expandable polyetheretherketone vertebral body replacement in osteoporotic vertebrae. BMC Musculoskeletal Disorders. 2025 Aug 20;26(1):806.

29. Elkholy H, El Nagar MA, Elnoamany N, Elsisi A, Aborahma H. Safety and Feasibility of Including the Fracture Level in the Fixation Construct for Traumatic Vertebral Fractures. Indian Journal of Neurotrauma. 2025 Aug 5.
30. Duan W, Zhao X, Chang L, Sun Z, Lai K, Zhang J, Tian B, Ye Z. Retrospective analysis of clinical and radiological outcomes. From Crosstalk Among Cell Populations in the Microenvironment of Bone Degenerative Diseases to the Novel Therapeutic Approaches. 2026 Mar 26:81.
31. Wen J, Su Y, Guo J, Fan S, Fang X, Chen J, Xu W. Vertebral fracture and spinal cord compression after removal of pedicle screws in PD patients: case report and literature review. Frontiers in Surgery. 2025 Dec 3; 12:1690927.
32. Tian D, Zhong H, Zhu B, Chen L, Jing J. Unilateral biportal endoscopic technique combined with percutaneous transpedicular screw fixation for thoracolumbar burst fractures with neurological symptoms: technical note and preliminary report. Journal of Orthopaedic Surgery and Research. 2023 Aug 8;18(1):584.
33. Beucler N. Single-staged three columns reconstruction of thoracolumbar AO Spine A4 burst fracture with traumatic canal stenosis causing neurological deficit using posterior open monoaxial pedicle screw distraction fixation, laminectomy, and titanium jack implant expansion kyphoplasty to avoid the need for corpectomy: an elegant proof-of-concept case. Neurosurgical Review. 2024 Jun 12;47(1):267.
34. Teli MG, Amato-Watkins AC. Posterior segmental fixation for thoraco-lumbar and lumbar fractures: a comparative outcome study between open and percutaneous techniques. British Journal of Neurosurgery. 2024 Jul 3;38(4):838-43.

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