

Thoracolumbar Burst Fractures: A Systematic Review and Meta-Analysis on the Anterior and Posterior Approaches

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Abstract:

Background: A thoracolumbar burst fracture (BF) is a severe type of compression fracture, which is the most common type of traumatic spine fractures. Generally, surgery is the preferred treatment, but whether the optimal approach is either an anterior or a posterior approach remains unclear. This study aims to determine whether either method provides an advantage.

Methods: Following PRISMA guidelines, a systematic review was conducted, identifying studies comparing anterior versus posterior surgical approaches in patients with thoracolumbar BFs. Data were analyzed using Review Manager 5.3. Seven studies were included.

Results: An operative time of 87.97 min (53.91, 122.03; $p < 0.0001$) and blood loss of 497.04 mL (281.8, 712.28; $p < 0.0001$) were lower in the posterior approach. Length of hospital stay, complications, reintervention rate, neurological outcomes, postoperative kyphotic angle, and costs were similar between both groups.

Conclusions: Surgical intervention is usually selected to rehabilitate patients with BFs. The data obtained from this study suggest that a posterior approach represents a viable alternative to an anterior approach, with various advantages such as a shorter operative time and decreased bleeding.

Keywords:

Thoracic, Lumbar, Thoracolumbar, Burst Fractures, Anterior, Posterior

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Introduction

The spine's role in axial-load bearing with a multidimensional range of motion makes it susceptible to various mechanisms of injury. Burst fractures (BFs), related to axial-load traumatic kinematics, are one of the possible outcomes, the others being impaction fractures and split fractures, as seen in the AOSpine Thoracolumbar Spine Injury Classification System¹⁾.

BFs occur most commonly in high-energy trauma scenarios, such as high-altitude falls²⁾ or motor vehicle accidents³⁾. Based on the three-column model, BF results because of a mechanical failure of the anterior and middle columns while under compression. The most important characteristic is the potential disruption of the posterior wall of the vertebral

body, followed by the retropulsion of bone fragments into the medullary canal, leading to neurological damage⁴⁾.

The thoracolumbar region of the spine is the most common site for BFs⁵⁻⁷⁾. The most frequent clinical presentations are back pain, decreased height/height shortening, restricted range of motion, and focal sensory or motor neurological deficits⁸⁾. The importance of increasing our understanding and of elucidating the optimal treatment of BF are highlighted by the fact that compression fractures are the most common type of traumatic spine fractures^{2,6)}, as well as the negative impact of spine lesions on the patient's quality of life and functionality^{9,10)}.

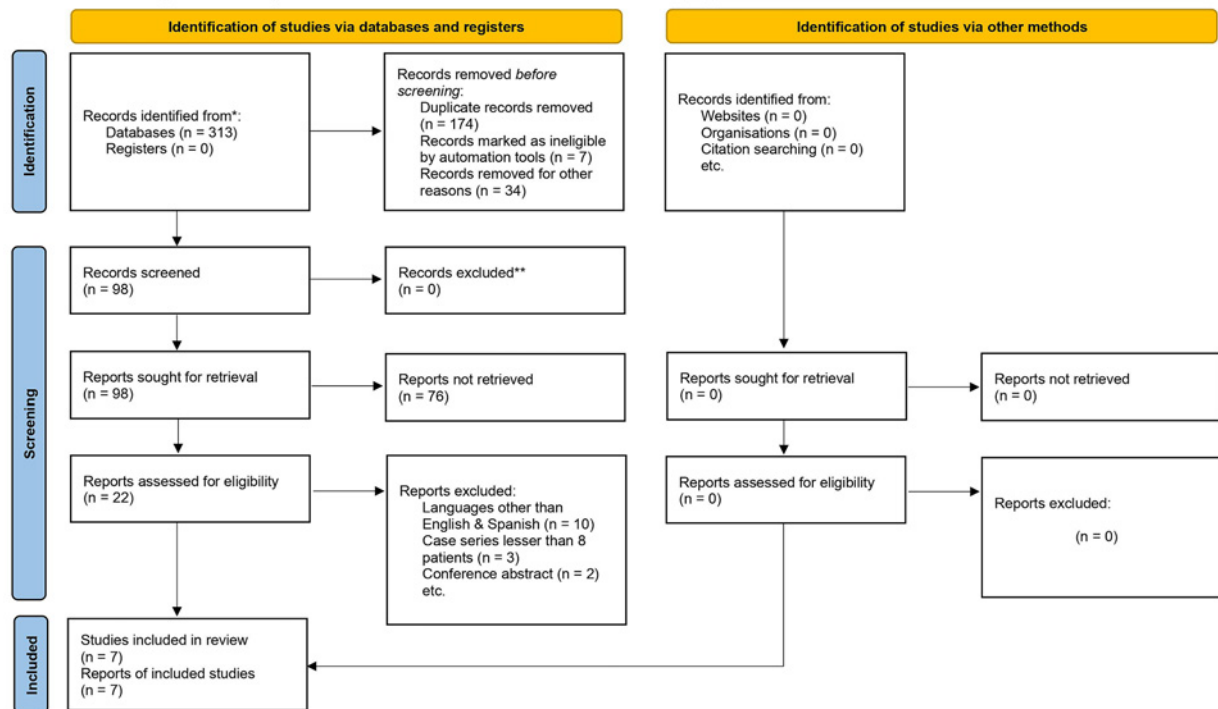
The decision on whether to treat BFs surgically or conservatively, especially when patients do not have a neurological deficit, is complicated. Although conservative treatment has

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PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: <http://www.prisma-statement.org/>

Figure 1. The PRISMA flowchart for the systematic review.

shown comparable outcomes with the surgical approach in several studies¹¹⁻¹⁴, not all patients have shown an improvement. Predictors of the failure of conservative treatment have been studied, and a greater age and interpedicular distance are the most distinguished¹⁵. When surgical treatment is preferred, the optimal selection of an approach remains unclear, as both procedures, anterior and posterior, have reported advantages and disadvantages, and recent studies have shown no differences among various outcomes^{8,13,16,17}. Factors such as fracture type, stability, degree of canal encroachment, and neurological status should be studied to determine the ideal type of surgery^{13,16}.

This study aims to evaluate and analyze all the available evidence on various clinical parameters by a systematic review, to determine the actual advantages and disadvantages associated with each technique and provide a summary.

Materials and Methods

Literature search strategy

In November 2020, following the Preferred Inventory for Systematic Reviews and Meta-Analysis (PRISMA), a systematic search was performed in Medline, Web of Science, Scopus, and Google Scholar databases, identifying studies comparing the anterior and posterior surgical approaches for thoracolumbar BFs (Fig. 1)¹⁸. The search terms used in titles and abstracts were “Spinal burst fractures,” “thoracolumbar burst fractures,” “Anterior AND thoracolumbar burst frac-

tures,” “Posterior AND thoracolumbar burst fractures,” and “thoracolumbar burst fractures treatment.” The MeSH terms included were “Humans,” “Lumbar,” “Thoracic,” “Treatment outcome,” “Operative time,” “Operative bleeding,” “Postoperative complications,” and “Costs,” including derived singular and plural variants.

Related articles and similar articles functions were also screened.

Study inclusion

Included studies provided clear statistical comparisons of an anterior versus a posterior surgical approach for thoracolumbar BFs and reported at least one of the following outcomes: intraoperative time and blood loss; postoperative length of hospital stay (LoS), kyphotic angle, construct failure, return to work, overall cost, need for reintervention, and complications. Restrictions on included studies were conference abstracts, case reports, and case series of fewer than eight patients. Studies with overlapping populations were excluded.

Data screening and extraction

Manuscripts were screened independently by two reviewers for inclusion, with manuscripts matching inclusion criteria retrieved for further data extraction. Primary extracted data included those variables mentioned previously in the study inclusion criteria. Any discrepancies were solved by a third reviewer and senior neurosurgeons.

Quality assessments

Studies were graded independently using the Newcastle-Ottawa Scale by each reviewer¹⁹.

Statistical analyses

Statistical analyses were performed using Review Manager version 5.3 (Cochrane). Heterogeneity was measured using the I^2 index, to which studies yielding values over 50% were considered heterogeneous and analyzed through random-effects models. Studies yielding values under 50% were considered homogeneous and were analyzed through fixed-effects models. Continuous variables were analyzed using standardized mean differences with a 95% confidence interval. Dichotomous variables were analyzed using odds ratios with 95% confidence intervals as well.

If included studies reported variables of interest as the median and range or median and interquartile range, the mean and standard deviation were estimated using Wan's methodology²⁰. For studies that included means but not a standard deviation, but had enough data (p-value and group sizes), Cochrane's Handbook for Systematic Reviews of Interventions, Version 6.1 was used to estimate the standard deviation using the t-value²¹. Estimations on the impact of intervention as defined by changes to means and standard deviations were calculated as follows:

$$\text{Mean change} = \text{Mean endpoint} - \text{Mean baseline}$$

$$\text{Mean Standard Deviation Change} = \frac{\sqrt{(\text{Baseline SD})^2 - (\text{Final SD})^2 - (2 * 0.04 * \text{Baseline SD} * \text{Final SD})}}{2}$$

For neurological outcomes, Frankel classification results were grouped as D and E scores for good, C for intermediate, and A and B for poor neurological outcomes. For analyses, the number of cases in each grouping was totaled and compared against each other.

Results

Overall

Seven studies met inclusion criteria, totaling 322 patients, of whom 155 underwent an anterior approach and 167 underwent a posterior approach. The summary of the analyses is displayed in Table 1, 2. Subgroup analysis featuring segregation by publication year cutoff was performed for each variable.

Demographic/Baseline Characteristics

Age

Six studies described age, totaling 131 patients in the anterior approach group and 129 patients in the posterior approach group. A meta-analysis of these data revealed a mean difference of -1.37 ($-4.24, 1.51$; $p=0.35$), showing non-different ages in the included cohorts allocated to each group. These findings are displayed in Fig. 2A.

Intraoperative Outcomes

Operative outcomes analyzed included the intraoperative time and bleeding volume. Included studies ranged from one to six. The findings are described below.

Operative time

Seven studies described the operative time, totaling 155 patients in the anterior approach group and 167 in the posterior approach group. A meta-analysis of these data revealed a mean difference of 87.97 min ($53.91, 122.03$; $p<0.00001$). These findings suggest that the posterior approach is associated with a significantly shorter operative time than the anterior approach. This finding is displayed in Fig. 2B.

Intraoperative bleeding

Six studies described intraoperative bleeding, totaling 155 patients in the anterior group and 167 in the posterior group. A meta-analysis of these data revealed a mean difference of 497.04 mL ($281.80, 712.28$; $p=0.00001$). These findings conclude that posterior approach procedures result in significantly lower intraoperative bleeding than anterior approach procedures. This finding is displayed in Fig. 2C.

Postoperative Outcomes

Postoperative outcomes of interest included LoS, complication and reintervention rates, postoperative changes in kyphotic angle, postoperative Frankel grade, and costs. Included studies ranged from two to five, and findings are discussed below.

Length of stay

Six studies described postoperative LoS, totaling 131 patients in the anterior approach group and 129 in the posterior approach group. A meta-analysis of these data revealed a mean difference of 5.12 days ($-0.74, 10.99$; $p=0.09$). These findings suggest that both approaches have similar LoS. These findings are displayed in Fig. 3A.

Complications

Six studies described complications, totaling 131 patients in the anterior approach group and 129 in the posterior approach group. A meta-analysis of these data revealed an odds ratio of 0.51 ($0.09, 2.83$; $p=0.44$). These findings suggest both approaches have similar complication rates. These findings are displayed in Fig. 3B.

Reinterventions

Four studies described reintervention, totaling 96 patients in the anterior approach group and 94 in the posterior approach group. A meta-analysis of these data revealed an odds ratio of 0.57 ($0.04, 7.59$; $p=0.67$). This suggests that both approaches possess similar reintervention rates. These findings are displayed in Fig. 3C.

Table 1. Summary of Key Findings from Included Studies.

Author	Year	Study Type	Patients (n)			Mean Age (y)	Mean Operative Time (min)		Mean Operative Bleeding (mL)	Mean Blood Transfusion	Mean Length of Stay (days)	Complications (events)		Reinterventions (events)		Mean Immediate Kyphotic Angle		Mean Follow-up Kyphotic Angle		Frankel Grade (events)		Cost (USD)					
			Total	ANT	POST		ANT	POST				ANT	POST	ANT	POST	ANT	POST	ANT	POST	ANT	POST	ANT	POST	ANT	POST		
Danisa	1995	Retrospective	43	16	27	37.95	42.35	438	219	1878	1103	4.6	2.3	13	10	4	4	0	1	-10	-8.7	-6.3	-5.7	15	25	63.963	45.306
Stancic	2001	Prospective clinical trial	25	13	12	35.75	36.5	248.75	173.25	1343.5	750	N.D.	N.D.	17.9	10.95	2	1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	2.665.2	2.213
Wood	2005	Prospective, randomized	38	20	18	38	42.75	236.5	218.75	804.5	492.5	5	5	7.85	13.3	3	17	0	11	-4.75	-5	1.25	3.75	N.D.	N.D.	N.D.	N.D.
Wang	2015	Prospective, randomized	66	22	23	37.2	40.5	198	110	570.8	357	N.D.	N.D.	18.5	13.5	1	3	N.D.	N.D.	0.8	1.0	8.9	9.8	N.D.	N.D.	7.084	4.859
Hitchon	2006	Retrospective	63	38	25	43	42.5	415	413	N.D.	N.D.	N.D.	N.D.	17	19	2	5	2	1	N.D.	N.D.	N.D.	N.D.	31	19	89.090	80.040
Wu	2013	Prospective	62	24	38	N.D.	N.D.	176.3	94.1	255.1	143.3	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Shin	2020	Control: retrospective Experimental: prospective	46	22	24	46.7	45.2	310.7	180.45	1566.6	289.2	N.D.	N.D.	49.65	17.45	3	0	3	0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

ANT=anterior; POST=posterior; N.D.=no data

Table 2. Summary of Findings from Our Meta-Analyses of Key Variables.

Outcomes	Studies	ANT	POST	WMD/OR (95% CI)	p-Value	Heterogeneity				
						χ^2	df	I ² (%)	p-Value	
<i>Demographic</i>										
Age	6	131	129	-1.37 [-4.24, 1.51]	0.35	2.87	5	0	0.72	
<i>Intraoperative</i>										
Operative time	7	155	167	87.97 min [53.91, 122.03]	<0.00001	104.18	6	94	<0.00001	
Bleeding	6	117	142	497.04 mL [281.80, 712.28]	<0.00001	167.15	5	97	<0.00001	
<i>Postoperative</i>										
Length of stay	6	131	129	5.12 days [-0.74, 10.99]	0.09	79.37	5	94	<0.00001	
Complications	6	131	129	0.51 [0.09, 2.83]	0.44	18.95	5	74	0.002	
Reinterventions	4	96	94	0.57 [0.04, 7.59]	0.67	9.53	3	69	0.02	
<i>Kyphotic angle</i>										
Immediate	2	36	45	-0.74 [-4.44, 2.97]	0.70	0.16	1	0	0.69	
Follow-up	2	36	45	-1.39 [-5.81, 3.02]	0.54	0.17	1	0	0.68	
<i>Frankel grade</i>										
Good neurological outcomes	2	54	52	0.04 [-0.10, 0.18]	0.59	0.01	1	0	0.91	
Intermediate neurological outcomes	2	54	52	0.04 [-0.07, 0.15]	0.60	0.22	1	0	0.64	
Poor neurological outcomes	3	54	52	-0.08 [-0.18, 0.02]	0.11	3.26	1	69	0.52	
Costs	4	89	87	1.86 [0.12, 3.60]	0.04	272.30	3	99	<0.00001	

ANT=anterior; POST=posterior; WMD=Weighted Mean Difference; OR=odds ratio; CI=confidence interval. Costs are represented on a scale of a thousand.

Kyphotic angle

Two studies described the postoperative kyphotic angle in two moments, totaling 36 patients in the anterior approach group and 45 in the posterior approach group. First, the immediate postoperative kyphotic angle was described. A meta-analysis of these data revealed a mean difference of -0.74 (-4.44, 2.97; $p=0.70$). Second, an outpatient follow-up kyphotic angle was also described. A meta-analysis of these data revealed a mean difference of -1.39 (-5.81, 3.02; $p=0.54$). This suggests similar kyphotic angles with both approaches. These findings are displayed in Fig. 4A, 4B.

Postoperative Frankel grade

Two studies described a Frankel score, totaling 54 patients in the anterior approach group and 52 in the posterior approach group. A meta-analysis of the good neurological outcome group data revealed an odds ratio of 1.36 (0.45, 4.09; $p=0.59$). A meta-analysis of the intermediate neurological outcome group revealed an odds ratio of 1.39 (0.41, 4.78; $p=0.60$). Only Hitchon et al.²² described three postoperative patients with a bad neurological outcome after undergoing a posterior surgical approach. This suggests that both approaches have similar rates of neurological outcomes. These findings are displayed in Fig. 4C.

Costs

Four studies described costs, totaling 89 patients in the anterior approach group and 87 in the posterior approach group. A meta-analysis of these data revealed a mean difference of 1.86 (0.12, 3.60; $p=0.04$). These findings suggest that both approaches have similar costs. These findings are displayed in Fig. 4D.

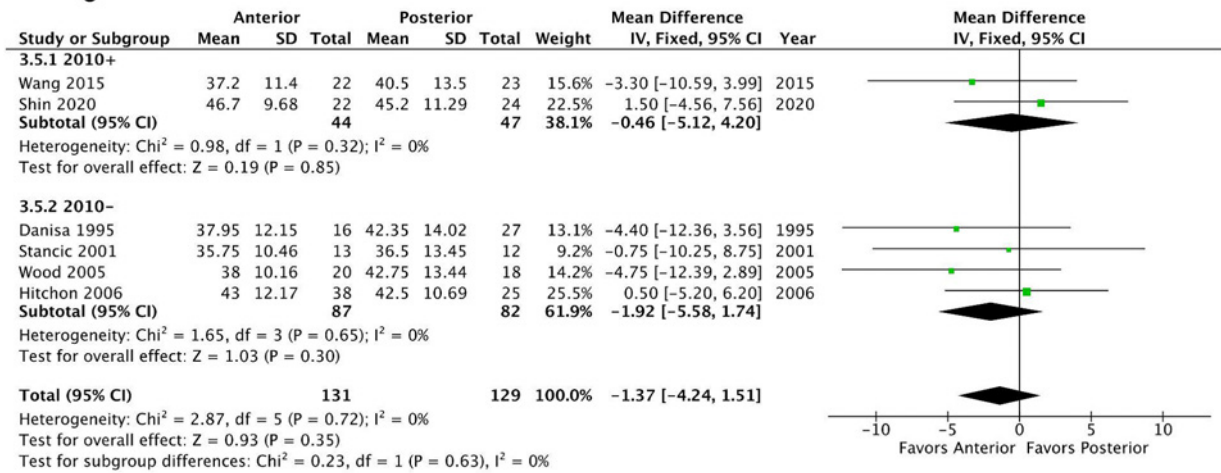
Discussion

Compression fractures, such as BFs, are the most frequent type of traumatic spine fractures^{2,6}. BFs can be managed through anterior, posterior, or a combination of both approaches. A better understanding of the potential benefits of surgical against conservative treatment, and subsequently, the strengths and shortcomings of the anterior and posterior approaches could aid in the selection of the most favorable treatment for each patient, which is important as BFs have a detrimental impact on patients' quality of life even after undergoing surgical treatment^{9,23}.

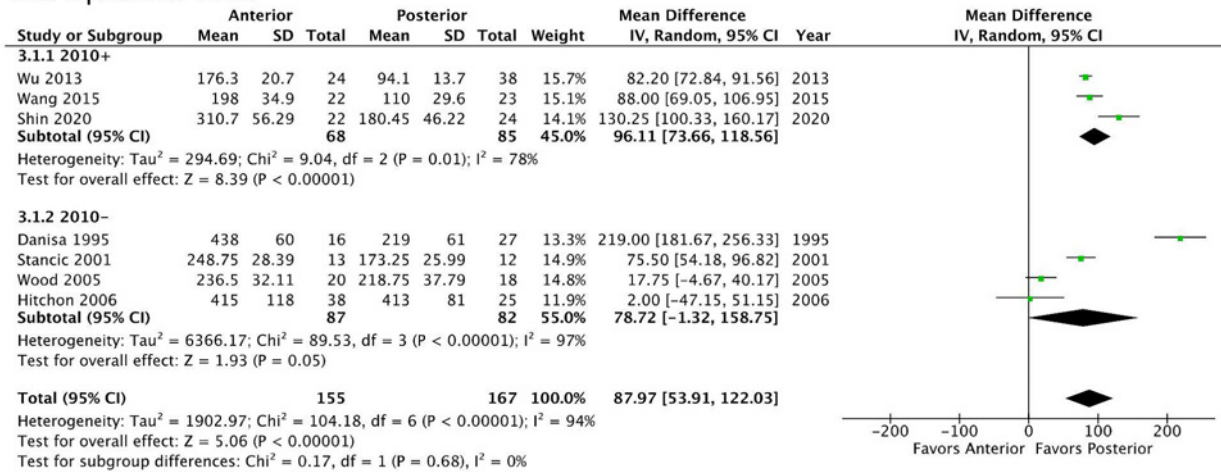
Several published studies have compared the conservative and surgical treatment of BFs without neurological deficit; nevertheless, the decision to operate or not remains controversial, in as much as, overall, both approaches have shown comparable outcomes^{11,24-26}. It is worth restating that a greater age and interpedicular distance seem to be predictors of failure of conservative treatment¹⁵. In our meta-analysis, the demographic analysis revealed that age was homogeneous among both groups; hence, operative and postoperative results were not biased by this factor. The evidence regarding nonoperative vs. operative treatment in patients with BF without a neurological deficit is much more limited, given that traditionally, a neurological deficit has been a strong indication for surgical treatment. However, there is some evidence that conservative treatment may be safe and patients can benefit from it^{12,13,27}.

Advocates of the anterior approach argue that this technique offers advantages such as the possibility of a better window for spinal canal decompression^{8,28}. Conversely, the posterior approach has demonstrated benefits such as a shorter operative time and less blood loss⁸. Ultimately, when

2.A Age



2.B Operative Time



2.C Intraoperative Bleeding

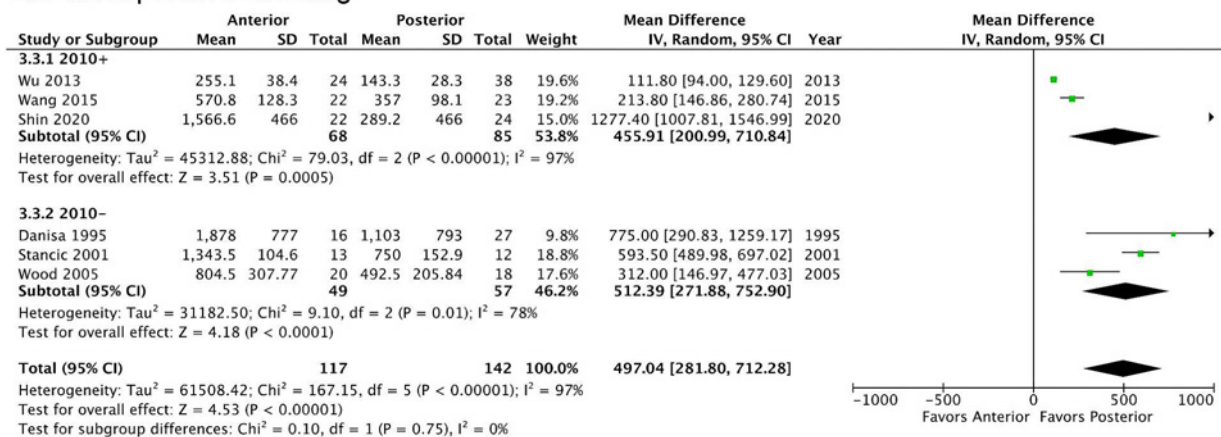
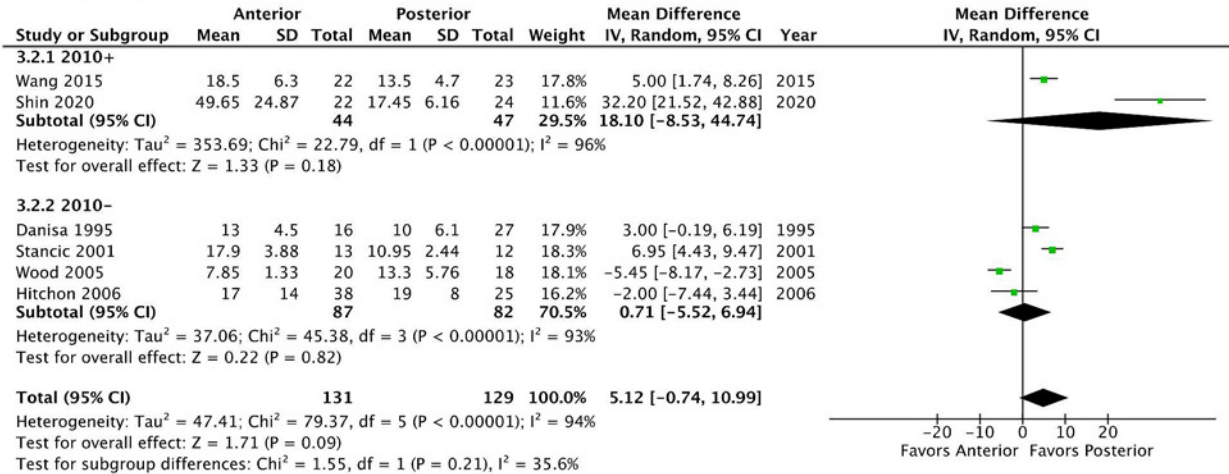


Figure 2. Forest plots of meta-analysis of the following variables: (A) age, (B) operative time, and (C) intraoperative bleeding.

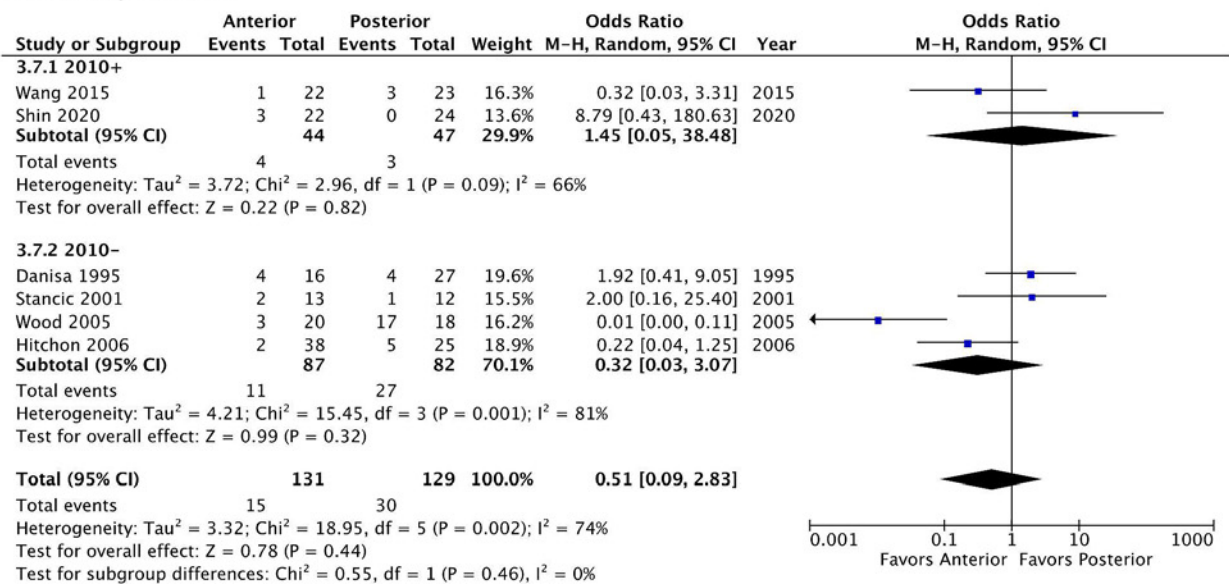
selecting the operative approach for the patient, the surgeon must consider various factors before making a decision, including the surgeon’s experience, fracture type, neurological status, and medullary canal compromise degree, among others.

We performed a meta-analysis including seven studies. Our study revealed that posterior approach procedures are associated with a significantly shorter operative time than anterior approach procedures (p<0.0001); similar results were reported in two other meta-analyses^{8,17}. Additionally,

3.A Length of Stay



3.B Complications



3.C Reinterventions

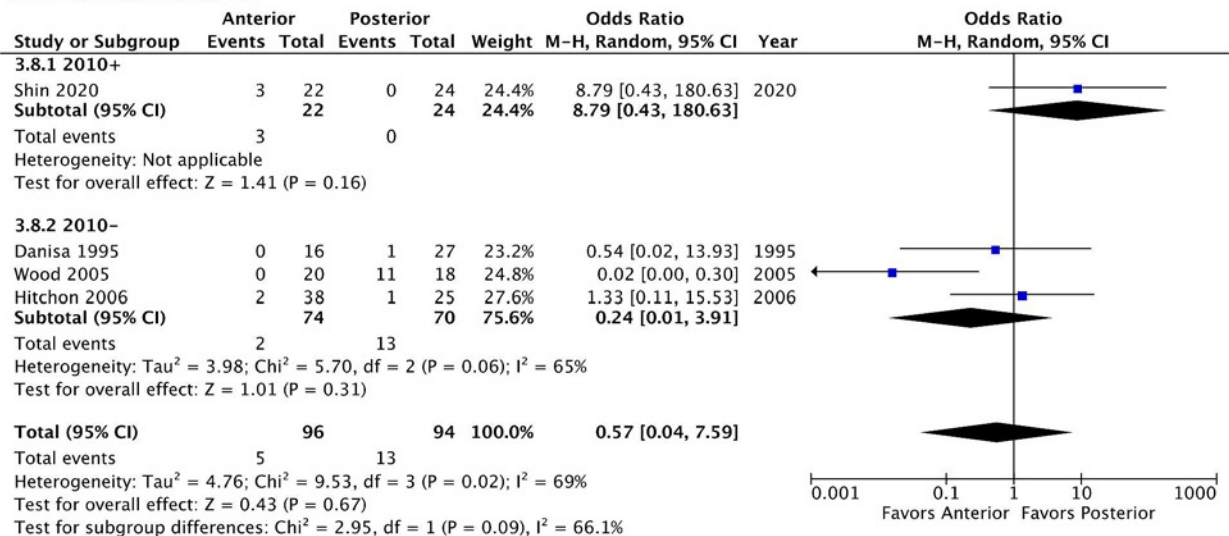
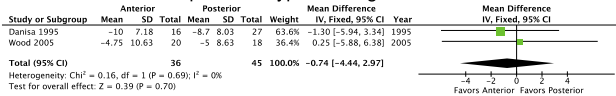
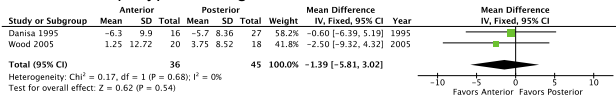


Figure 3. Forest plots of meta-analysis of the following variables: (A) length of hospital stay, (B) complications, and (C) reinterventions.

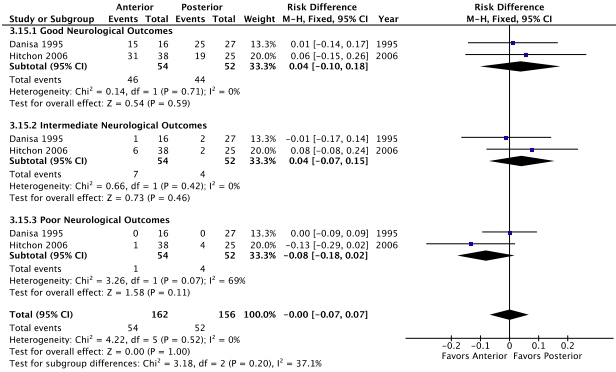
4.A Immediate Postoperative Kyphotic Angle



4.B Follow-up Kyphotic Angle



4.C Postoperative Frankel Grade



4.D Costs

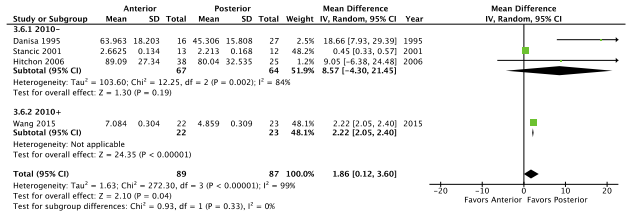


Figure 4. Forest plots of meta-analysis of the following variables: (A) immediate postoperative kyphotic angle, (B) follow-up kyphotic angle, (C) postoperative Frankel grade, and (D) costs. Note: for better visualization, costs are represented on a scale of a thousand.

posterior approaches result in significantly lower intraoperative bleeding than anterior approaches; this coincides with the results of Xu et al. (2013)⁸, and Tan et al. (2019)¹⁷. This has clinical significance as blood transfusion in patients undergoing spine surgery increases the LoS and minor complications²⁹, and entails a higher cost of hospitalization³⁰.

Our analysis shows that both approaches undergo similar LoS. Interestingly, this concurs with the results of Tan et al. (2019)¹⁷, in which an anterior approach had a significantly longer operative time and increased blood loss, but contrasts with findings in another meta-analysis conducted by Shin et al.¹⁶, in which a posterior approach had a significantly lower LoS. We found similar kyphotic angles with both approaches. Notably, one retrospective study showed no correlation on long-term follow-up between residual kyphosis and improved patient outcomes, or with back pain³¹. Our meta-analysis shows that anterior and posterior approaches possess similar reintervention and complication rates, which may be explained in part by refined surgical techniques and expertise.

Regarding neurological outcomes, our study found no significant differences among both approaches. Despite the fact that the surgical procedure aims to improve the patient's neurological status and avoid deterioration, to ensure an increase in the quality of life, it is noteworthy that the initial lesion itself is the main cause of decreased quality of life after BFs⁹ and that certain computed tomography parameters (compression ratio of median sagittal diameter, anterior vertebral compression ratio, among others) observed before surgery have a strong association with the neurological defi-

cit³². We consider it relevant to mention that three of the six studies we analyzed were retrospective and that this type of methodology may significantly underestimate the incidence of complications (including neurological-related complications) in spine surgeries³³.

Patients undergo surgical intervention to improve their prognosis, decrease mortality, and increase their quality of life; studies comparing different approaches are conducted with the justification of investigating which treatment better accomplishes these goals. Future studies should aim to further establish the role of anterior, posterior, or combined approaches, and could start comparing these therapies in non-trauma-related BFs, such as osteoporosis or seizures.

For future studies, we encourage authors to include cost analysis, ideally, for every outcome of interest (LoS, transfusions, reinterventions, rehabilitation, and pain management). Only three out the seven studies we analyzed added cost analysis; this information could be of great value for hospital administration and in the interest of patients. Future studies could also perform subgroup analyses of minor grouping features that could impact outcomes, such as age, fracture level, preexisting conditions, and concomitant lesions, among others.

Finally, even though our meta-analysis yielded the posterior approach as superior in various aspects, such as operative time and intraoperative bleeding, we suggest that the selection of treatment modality be made by an individualized process, and decisions made according to the patient's characteristics, hospital settings, and other similar factors.

Strengths and limitations

This study has various limitations, stemming from heterogeneity in reporting and a low volume of available literature over a wide span of years. Neurological outcomes in future studies would benefit from more detailed reporting, as the available literature scarcely described neurological outcomes. These were measured as postoperative totals and may not truly reflect the impact surgical intervention may have on function. Further limitations stem from study quality, as a minority are randomized studies. We encourage future studies to include a wider analysis and data on neurological outcomes and repercussions of these treatment options as well as wider patient populations.

Conclusion

Surgical intervention is usually selected to rehabilitate patients with BFs; the data obtained in this study suggest that a posterior approach represents a viable alternative to an anterior approach when comparing outcomes in the short-term postoperative period. Various advantages, such as a shorter operative time and decreased bleeding, were identified. Further evidence is needed to accurately define the indications for each approach and the decision of which surgical approach is selected should be an individualized process, taking into account surgical expertise and resources available within the hospital setting.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

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Author Contributions: ARM designed the study, conducted statistical analyses, wrote and edited this article. ETG gathered data, conducted data analysis, and interpreted and edited this article. LCBG participated in the study design and contributed extensively to the editing and writing of this article. JBVE and JRRB gathered data. CAGG participated in study conceptualization, design, analysis, and editing. EFV and JAFS participated in study conceptualization, design, gathering of data, and editing. DEHG designed the study, conducted statistical analyses, and wrote this article.

Ethical Approval: Approval was not required from the Institutional Review Board because this is a review article.

Informed Consent: Consent was not required because this study involved no human subjects.

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