META-ANALYSIS

Influence of Posterior Spinal Surgery Drainage on Hematoma and Infections at Surgical Sites: A Systematic Review and Meta-Analysis

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ABSTRACT

Objective • The primary objective of this systematic review and meta-analysis was to assess the effectiveness of postoperative drainage in reducing the incidence of Surgical Site Hemorrhage (SSH) and Surgical Site Infections (SSI) in patients undergoing posterior spinal surgery.

Methods • We conducted a comprehensive search of four electronic databases, including PubMed, Embase, Web of Science, and Cochrane Library, to identify relevant studies. Only Randomized Controlled Trials (RCT) focusing on patients diagnosed preoperatively with non-infectious spinal diseases and undergoing posterior spinal surgery were included. The meta-analysis examined the efficacy of postoperative drainage in reducing SSH and SSI incidence. Quality assessment was performed using the Cochrane Collaboration's Risk of Bias tool. Statistical analyses were conducted to evaluate heterogeneity and publication bias.

Results • A total of seven studies met the inclusion criteria for SSH analysis, while six studies were included in the SSI analysis. The findings revealed a significant reduction in the incidence of SSH in patients with postoperative drainage, with a Relative Risk (RR) of 0.35 (95% CI: 0.20 to 0.62, $P < .01$). However, no statistically significant impact was observed on the incidence of SSI (RR: 0.97, 95% CI: 0.36 to 2.59, $P = .81$). Funnel plot symmetry and Egger's linear regression test confirmed the absence of significant publication bias.

Conclusions • The use of postoperative drainage in posterior spinal surgery is recommended to significantly reduce the risk of SSH. However, its effectiveness in preventing SSI remains inconclusive and requires further investigation. These can inform clinical decision-making and potentially improve patient outcomes. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

Posterior spinal surgery is a commonly employed and crucial treatment approach for a range of spinal disorders, such as deformities, traumatic injuries, degenerative diseases, and tumors. However, this procedure carries potential complications, including surgical site hematoma (SSH) and surgical site infection (SSI), which can result in significant morbidity and mortality. Therefore, reducing the occurrence of these complications is of utmost importance in promoting successful outcomes. To mitigate the risks of SSH and SSI, surgical drainage has traditionally been utilized as a preventive measure. The rationale behind this practice is to prevent the accumulation of blood and fluids, which may serve as a breeding ground for bacterial growth. However, the efficacy and necessity of surgical drainage in posterior spinal surgery remain subjects of debate and controversy. The existing literature reports inconsistent outcomes, highlighting the need for a comprehensive evaluation to establish optimal practices. In order to address this issue, it is essential to provide a thorough understanding of the significance of SSH and SSI in posterior spinal surgery. Additionally, exploring the current controversies surrounding the use of surgical drainage can shed light on the need for a systematic evaluation of its benefits and drawbacks. By conducting such an evaluation, healthcare professionals can make informed decisions regarding the implementation of surgical drainage, ultimately improving patient outcomes and reducing the incidence of complications.[1-3] Wound drainage has long been employed as a preventive measure to mitigate these risks. The rationale behind drainage is to prevent the accumulation of blood and fluids that could create a medium for bacterial growth. Yet, its efficacy and necessity are still contentious,[4] with studies showing varied outcomes, indicating a need for a systematic evaluation to determine the best practices. Therefore, this study aims to comprehensively evaluate the role of surgical drainage in posterior spinal surgery.

SSH is a particularly troubling postoperative complication. It may lead to compressive spinal cord injuries, increasing tension on the incision, impeding healing, or even causing rupture, leading to SSI. These challenges are not only clinical concerns; they exacerbate nursing difficulties, require additional medical interventions, and escalate medical costs for both patients and healthcare systems. SSH can also result in neurological deficits, causing lasting impairment or disability. The prevention of SSH and subsequent SSI is thus a critical aspect of patient care and recovery, influencing not only the immediate postoperative period but potentially impacting long-term quality of life. Incision drainage can also bring about retrograde infections, escalate postoperative blood loss, and necessitate further treatments such as debridement and blood transfusion.[5,6] This illustrates that while drainage can be beneficial, it may also present inherent risks and complications. Retrograde infections can result from bacterial contamination of the drainage system, potentially leading to systemic infections. Moreover, the drainage process can sometimes be inefficient, leading to a retained hematoma or overly aggressive, causing excessive blood loss. The decision whether to employ drainage is complex and requires a nuanced understanding of the surgical context, patient factors, and emerging evidence. Such complexities underline the urgent need for a methodical analysis to delineate the risks and benefits of drainage in the specific setting of posterior spinal surgery.

With the introduction of ERAS protocols, some researchers advocate against drainage when there are no preoperative coagulation abnormalities and hemostasis is achieved intraoperatively. Yet, the necessity of drainage following posterior spinal surgery remains controversial, highlighting the need for evidence-based guidance. Randomized controlled trials (RCTs) represent a gold standard for evaluating medical interventions.[7] However, there is a significant gap in the comprehensive synthesis of RCT findings regarding drainage in posterior spinal surgery. Systematic reviews and meta-analyses based on RCTs are considered the highest level of evidence in evidence-based medicine (EBM),[8] underscoring the importance of this study. Therefore, this research undertakes a meta-analysis of existing RCT results on posterior spinal surgery drainage, comparing the occurrence rates of SSH and SSI in drainage and non-drainage groups. The findings of this systematic review and meta-analysis could serve as a cornerstone in clinical decision-making, enhancing patient safety, improving resource utilization, and potentially revolutionizing current surgical practices.

MATERIALS AND METHODS

Search strategy

Adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was maintained throughout the systematic review process and subsequent reporting of our results.(PRISMA) guidelines.[9] The review focuses on Patients (P) who are undergoing posterior spinal surgery. The primary Intervention (I) under examination is the implementation of drainage post-surgery, compared to (C) against no drainage or different drainage techniques. Our outcomes of interest (O) include the incidence of SSH, SSI, postoperative blood loss, the necessity for further treatments such as debridement or blood transfusion, and any associated morbidity or mortality.

Four electronic databases, the PubMed, Embase, Web of Science, and Cochrane Library databases, were searched on July 19, 2023, and no time limitation was applied. The search strategy will involve key terms such as "spine," variations of "drain," including "drain*" and "drainage," "suction," "hematoma," "infection*," and "random*." These keywords have been specifically selected to encompass the broad scope of the PICO framework and ensure a comprehensive retrieval of relevant studies for this meta-analysis. No language limitation was applied. Reference lists of relevant articles were also screened manually for any additional possible records.

Inclusion criteria

The included studies needed to meet the following criteria: 1) Study Subjects: Patients diagnosed preoperatively with non-infectious spinal diseases. 2) Surgical Procedure: All cases involving posterior spinal surgery; 3) Intervention Measures: The intervention group underwent surgical wound drainage, while the control group did not undergo wound drainage; 4) Outcome Indicators: The study must report on SSH incidence rate and/or SSI incidence rate; 5) Study Type: Only RCTs are included.

The exclusion criteria were as follows: 1) Duplicate Publications: Studies that have been published more than once; 2) Inaccessibility of Full Text: Studies where the full text is not available; 3) Incomplete Statistical Data: Studies with incomplete statistical data that prevent meta-analysis; 4) Case reports, expert opinion and conference papers.

Data extraction

In accordance with meta-analysis standards, two independent evaluators were responsible for conducting the literature review and data extraction processes. Each evaluator will cross-verify the extracted data to ensure consistency and accuracy. In the event of any discord during this phase, the adjudicating reviewers engaged in collegial discussion to reconcile the differences and potentially sought the counsel of a third, impartial evaluator. The dataset for extraction encompasses several key parameters: primary authorship of the study, year of publication, the specific spinal pathology under scrutiny, the average age of the cohort, the cumulative case count, the length of post-surgical drainage implementation, the regimen of prophylactic antibiotics administered postoperatively, and the incidence of prespecified endpoints such as SSH and SSI. In instances where relevant data are absent from the published manuscript, investigators from the original study will be contacted via email to solicit the unavailable data.

Quality assessment

In adherence to rigorous standards for meta-analysis in medical research, the methodological quality of the incorporated studies will be gauged using the Cochrane Collaboration's Risk of Bias tool.[10] Two impartial assessors autonomously scrutinized various domains, including random sequence generation, concealment of allocation, blinding protocols for participants and staff, completeness of outcome data, selective outcome reporting, and any other plausible origins of bias. The risk in each domain will be categorized as either low, unclear, or high. Any divergences in assessments between the two reviewers were harmonized through deliberation, and, where essential, the arbitration of a third reviewer was sought.

Statistical analyses

To rigorously appraise the heterogeneity across the studies under review, both chi-square statistics and the I^2 metric were utilized. Heterogeneity was considered non-significant when the I^2 value fell below 50% and the associated $P \geq .10$. Under such circumstances, a fixed-effect model was invoked for the calculation of the aggregated effect size. Conversely, an I^2 value of 50% or higher, or an associated $P < .10$, signified substantial heterogeneity. In instances where statistical heterogeneity was present, a random-effects model was applied for amalgamating the effect sizes. To evaluate the potential for publication bias, the symmetry of the funnel plot was scrutinized. A balanced distribution of data points flanking the apex of the funnel plot indicated a lower probability of result distortion due to publication bias. Egger's linear regression test was implemented for a quantitative assessment of publication bias. All statistical evaluations were two-tailed, with a $P < .05$ considered statistically significant. Statistical analyses were conducted using Stata version 17 (StataCorp, College Station, TX, USA).

RESULTS

Search results and study selection

Following the initial search across electronic databases, a total of 1,019 pertinent articles were identified. After excluding duplicative studies and screening titles and abstracts according to pre-established inclusion and exclusion criteria, a total of 21 relevant publications were shortlisted. After comprehensive full-text evaluations, 14 articles were culled, culminating in the inclusion of seven studies for the final meta-analysis.[11-17] A schematic representation of the literature filtration protocol and outcomes is depicted in Figure 1.

Figure 1. Selection process of included studies.

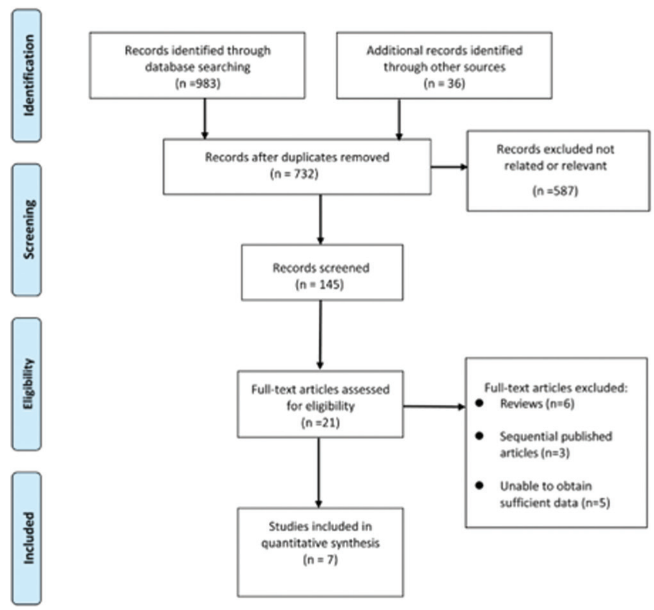


Table 1. Characteristics of studies included in the meta-analysis.

Author	Year of Publication	Diagnosed Spinal Condition	Mean Age (Years)	Male/ Female	Postoperative Drainage Duration (Days)	Duration of Prophylactic Antibiotics (Hours)
Guo	2020	Lumbar Disc Herniation	55	251/169	1-2	24
Ovadia	2019	Scoliosis	15.7	78/22	2-3	NA
Gubin	2019	Spinal Stenosis, Spondylolisthesis, Scoliosis, Kyphosis, Spinal Trauma, Spinal Tumor	48.1	64/91	NA	NA
Hung	2017	Lumbar Disc Herniation, Spondylolisthesis, Vertebral Fracture	62.6	20/36	NA	NA
Mirzai	2006	Lumbar Disc Herniation	46.7	29/21	1	NA
Brown	2004	Spinal Stenosis, Myelomeningocele, Vertebral Fracture, Post-Laminectomy Syndrome	67.4	NA	NA	NA
Payne	1996	Lumbar Disc Herniation, Spinal Stenosis	NA	NA	2	48

Abbreviation: NA, Not applicable.

Study characteristics

The studies under examination for this meta-analysis were published between 1996 and 2020 and encompassed a diverse range of diagnosed spinal conditions, including but not limited to Lumbar Disc Herniation, Spinal Stenosis, Scoliosis, and Vertebral Fracture. The age of patient populations in these studies varied considerably, with mean ages ranging from 15.7 to 67.4 years. In terms of gender distribution, there was considerable variation across studies, from gender-balanced cohorts to those significantly skewed towards either males or females. Information on postoperative drainage duration was sporadically reported, with observed durations ranging from one to three days. Regarding prophylactic antibiotic use, some studies reported durations as specific as 24 to 48 hours, while others lacked this data altogether (Table 1).

Results of quality assessment

In accordance with the academic standards requisite for meta-analysis publications, the risk of bias was meticulously scrutinized across various facets in the 7 incorporated studies. Two of these studies had a uniformly low risk of bias across all

Figure 2. Quality assessment of included studies using Cochrane Collaboration's tool criteria. Red in figure indicates high risk and green means low risk.

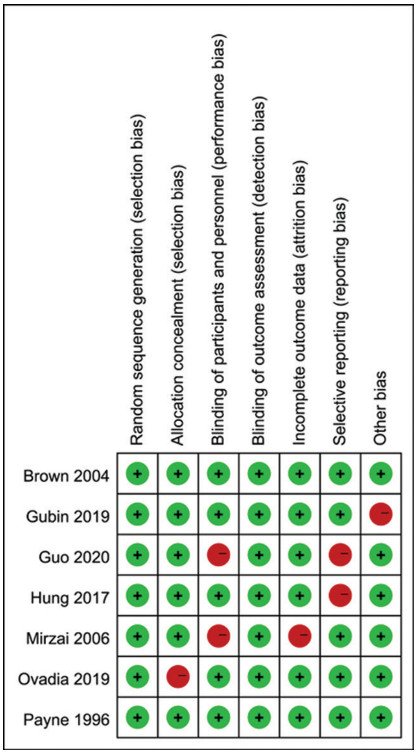


Figure 3. Forest plots of the incidence of surgical site hemorrhage.

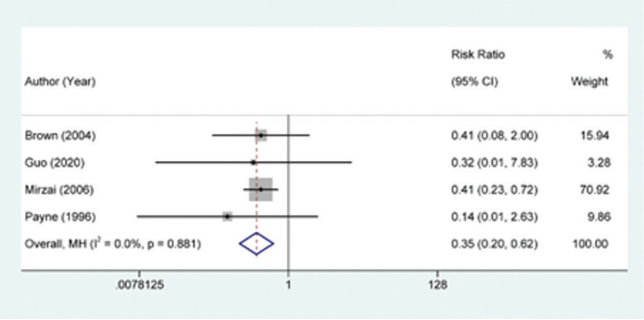


Figure 4. Forest plots of the incidence of surgical site infection.

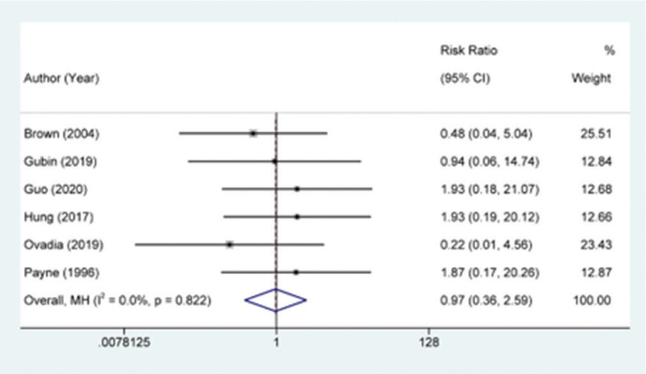
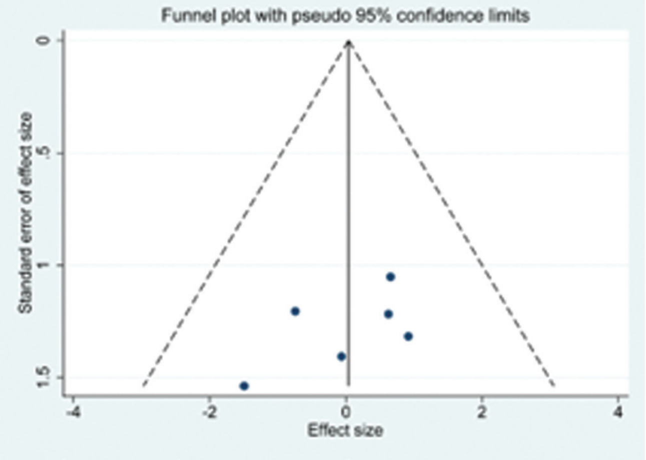


Figure 5. Funnel plot for publication bias in all included studies.



examined categories, reflecting a robust methodological integrity. Nevertheless, a considerable 28% of the studies exhibited a heightened risk of bias, specifically in the domain concerning the blinding of participants and personnel, potentially implicating the influence of performance bias on the study outcomes. Similarly, a high propensity for selective reporting bias was present in 28% of the included randomized controlled trials. This raises concerns about the veracity of the overall findings due to the potential for either incomplete or prejudiced reporting of outcomes (Figure 2).

Meta-analysis results on the incidence of surgical site hemorrhage

Four studies reported on the incidence of Surgical Site Hemorrhage (SSH), with no notable heterogeneity observed among these studies ($I^2 = 0\%$, $P = .881$). Accordingly, a fixed-effects model was employed for this particular meta-analysis. The results yielded a significant reduction in the occurrence of SSH in the drainage group compared to the non-drainage group. Specifically, the Relative Risk (RR) was calculated at 0.35 with a 95% Confidence Interval (CI) ranging from 0.20 to 0.62. The statistical significance was confirmed with $P < .01$. These results are graphically summarized in Figure 3.

Meta-analysis results on the incidence of surgical site infection

Six additional studies reported data on the incidence of SSI. Again, a low level of heterogeneity was observed among these studies ($I^2 = 0\%$, $P = .653$), justifying the application of a fixed-effects model. The meta-analysis failed to indicate any statistically significant difference in the incidence of SSI between the drainage and non-drainage groups. The calculated RR was 0.97, with a 95% CI extending from 0.36 to 2.59. The statistical insignificance of these findings was corroborated by a *P* value of .81. A graphical summary is provided in Figure 4.

Publication bias

The constructed funnel plots for the included studies exhibited symmetrical patterning, indicating the absence of substantial publication bias (Figure 5). Confirmatory analyses through Egger's linear regression test across multiple variables further substantiated the absence of significant publication bias (*P*-values exceeding .05 for all evaluated parameters), thereby fortifying the reliability and robustness of our meta-analytical outcomes.

DISCUSSION

The topic of postoperative drainage in posterior spinal surgeries remains uncertain and subject to professional disagreement. Particularly, the dispute centers on its influence on two major surgical complications—SSH and SSI—and whether or not the intervention mitigates these risks. The existing literature presents a panorama of conflicting results, leaving clinicians at a crossroads in their therapeutic choices.[18,19] Mirzai et al. provided evidence favoring drainage, with their research revealing a significantly higher incidence of epidural hematoma in non-drainage groups (89%) compared to drainage groups (36%) following lumbar disc excisions.[16] This data suggests the potential benefit of implementing drainage protocols, particularly for specific types of spinal surgeries. Conversely, Ovadia et al. counter this narrative, presenting data that does not substantiate a measurable difference in postoperative SSH or SSI between the drainage and non-drainage groups in patients undergoing posterior spinal surgeries for scoliosis.[17]

Given the juxtaposition of these contrasting viewpoints, our study sought to bridge the evidential gaps by employing a methodologically rigorous systematic review and meta-analysis, focusing solely on RCTs. In doing so, we aspire to present a balanced evaluation that synthesizes the disparate threads of existing data into a coherent tapestry of evidence-based recommendations. Our meta-analysis attempts to cut through the noise of conflicting opinions and offers a comprehensive overview to help inform medical practitioners in the ongoing debate. The contrasting findings of Mirzai et al. and Ovadia et al. only underscore the complexity of the issue and perhaps indicate that the utility of postoperative drainage may be contingent upon a myriad of variables, including surgical techniques, type of spinal pathology, and even patient-specific factors like coagulation profile and immunological status.[16,17]

Given the complexities and diverging scholarly viewpoints, there is a conspicuous need for further studies, especially multi-center RCTs, to address these discrepancies conclusively. Such research should aim to include diverse patient populations and multiple types of posterior spinal surgeries and perhaps even delve into the specific characteristics of drainage systems themselves—such as suction pressure or material—to provide a more nuanced understanding of their impact. Until then, clinicians should consider the existing body of evidence as part of a complex decision-making algorithm that takes into account individual patient risks, the nature of the surgical intervention, and the prevailing expert consensus in their specific medical community. By providing this synthesized evaluation, we aim to refine the decision-making process for clinicians involved in posterior spinal surgeries, thereby potentially enhancing surgical outcomes and reducing associated complications.

A pertinent issue here is the robustness of the meta-analysis results. A prior meta-analysis in 2016 by Liu et al. bears similarities to our findings; however, their study had several limitations. Most notably, Liu et al.'s analysis included only four RCTs, while the rest were non-randomized controlled trials, thereby lowering the evidence level of their meta-analysis.[20] Our study builds upon Liu et al.'s groundwork but significantly augments the quality of the evidence. We exclusively integrated newly published RCTs while eliminating non-randomized trials, thus fortifying the meta-analytic outcomes and enhancing the rigor of our conclusions.

Consequently, the results can be considered more robust and reliable. Our study amplifies the complexity of clinical decision-making concerning the utility of drainage systems in posterior spinal surgeries. While our data indicate significant advantages in reducing SSH, the same could not be stated for SSI. This bifurcation calls for a nuanced, case-specific approach to postoperative management. Clinicians must navigate this divided landscape by integrating diverse variables, including the patient's medical history, the complexity of the surgical procedure, and the potential risks of secondary complications.

The present study encompasses several methodological limitations and practical clinical implications that deserve thorough consideration. A significant constraint is the relatively small sample sizes across the included RCTs, which raises the possibility of Type II errors. Additionally, there is significant heterogeneity in the diseases addressed and the surgical methods employed in these studies, spanning from open to minimally invasive techniques and from single-segment to multi-segment interventions. To mitigate this heterogeneity, we confined our meta-analysis to studies utilizing posterior surgical approaches. Moreover, certain studies included variable durations for drainage tube retention and prophylactic antibiotic use, which could introduce confounding variables affecting the incidence of SSI. From a clinical standpoint, we noted that a majority of patients experience substantial levels of anxiety and fear towards postoperative drainage devices, potentially hindering early ambulation and thereby increasing the risk for complications like pressure ulcers and venous thromboembolism. This scenario complicates nursing care and escalates healthcare costs. In line with the Enhanced Recovery After Surgery protocols, there is a growing trend among clinicians to omit drainage devices in posterior spinal surgeries, especially when preoperative coagulation profiles are normal and intraoperative hemostasis is complete, thus diminishing the need for drainage as a therapeutic intervention.

CONCLUSIONS

Based on our findings, it is important for clinicians to carefully weigh the benefits of reduced SSH against the inconclusive evidence for SSI when deciding whether to implement postoperative drainage in posterior spinal surgeries. The decision should take into account individual patient risks, the nature of the surgical intervention, and the prevailing expert consensus in their specific medical community. Further research is needed in this area to provide more robust evidence on the effectiveness of drainage in reducing SSI.

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CONFLICT OF INTEREST
The authors have no potential conflicts of interest to report relevant to this article.

AUTHOR CONTRIBUTIONS
CZ, CG and LG designed the study, HH and JZ collected the data, JT and JC analyzed the data, CZ, CG and LG prepared the manuscript. All authors read and approved the final manuscript.

ETHICAL COMPLIANCE
Not applicable.

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