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REVIEW ARTICLE

Risk–benefit analysis of wound drain usage in spine surgery: a systematic review and meta-analysis with evidence summary

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Abstract

Study design Systematic review, meta-analysis, evidence synthesis.

Objectives To analyse the literature evidence available to support the usage of wound drain in various scenarios of spine surgery and provide an evidence summary on the surgical practice.

Materials and methods We conducted independent and duplicate electronic database searches adhering to PRISMA guidelines in PubMed, Embase, and Cochrane Library till April 2020. Quality appraisal was done as per Cochrane ROB tool, and evidence synthesis was done as per GRADE approach. Five domains of spine surgery with associated key questions were identified. Evidence tables were generated for each question and critical appraisal done as per the GRADE approach.

Results Twenty-three studies (9—RCTs, 4—prospective studies, 10—retrospective studies) were included. Analysis of studies in cervical spine either by anterior or posterior approach and single/multilevel thoracolumbar spinal surgeries did not show any evidence of reduction in surgical site infection (SSI) or haematoma formation with the use of drain. Deformity correction surgeries and surgeries done for trauma or tumour involving spine also did not find any added benefit from the use of wound drains despite increasing the total blood loss.

Conclusion Evidence from this review suggests that routine use of drain in various domains of spine surgery does not reduce the risk of SSI and their absence did not increase the risk of haematoma formation. The current best evidence is presented with its limitations. High-quality studies to address their use in spine surgeries in cervical, trauma, and tumour domains are required to further strengthen the evidence synthesised from available literature.

Keywords Wound drain · Spine surgery · GRADE · SSI · Haematoma

Introduction

With the widespread awareness of morbidity and health care expenditure caused by surgical site infection (SSI) in spine surgeries, a multi-faceted approach involving various peri-operative pharmacological and surgical measures were being ascertained to prevent its occurrence [1]. The use of surgical drain remains as one such surgical measure. The practice was mainly started in spine surgery to prevent the formation of epidural haematoma which could cause neurological deficit by its mass effect on the dural sac and increasing the tension on the incisions resulting in wound-related complications [2]. Wound drain being a double-edged sword, apart from supposedly aiding in SSI prevention, could cause retrograde infection, increase post-operative blood loss which increases the need for blood transfusion [3].

When asked about the use of wound drains among spine surgeons in Germany, there was heterogeneity in the reasons for their usage and lack of uniformity in the surgical practice [4]. This lack of consensus on the use of wound drains in spine surgeries was mainly due to the following reasons. While a few studies which dealt with the use of wound drains in spine surgery for a specific surgical scenario

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such as single-level lumbar fusion procedure or multilevel deformity correction procedures provide us with conflicting results on their usage [5, 6], many studies considered their use among multiple surgical scenarios altogether making a critical appraisal of their evidence a challenge for surgical practice [7, 8]. Hence, there is a need for a comprehensive evidence summary for the usage of wound drains in various surgical scenarios of spine surgery to bring about uniformity in the surgical practice to prevent SSI without any added risk to the patients.

So far, usage of drains in spine surgery was a practice made out of habit rather guided by evidence since no evidence summary has been generated from a systematic review on the use of wound drains in specific case scenarios of spine surgery [8]. Therefore, the following systematic review and meta-analysis with evidence summary compare the various potential outcomes with and without the use of wound drains in spine surgery to arrive at a consensus on this surgical exercise.

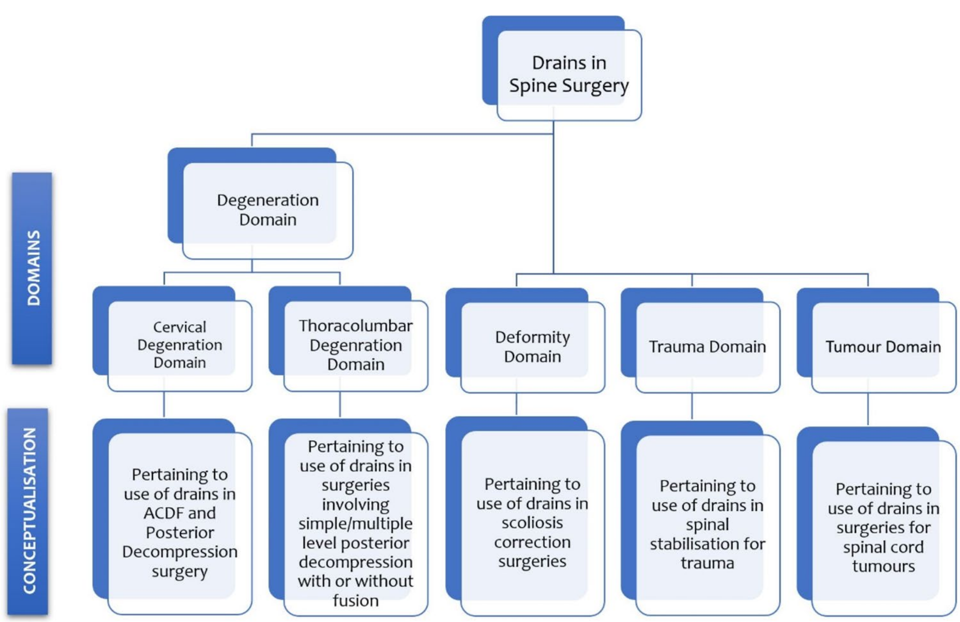
Materials and methods

This meta-analysis was conducted following the guidelines of Back Review Group of Cochrane Collaboration [9] and reported based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [10]. Evidence summary based on the strength and quality of the available evidence is made using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach [11].

Five domains of utilisation of the wound drain in spine surgery were conceptualised as shown in Fig. 1, and key questions for each domain were formulated and the level of evidence in literature was analysed. The final version of the key questions was determined after a consensus agreement between the authors.

1. Domain: **Cervical Degeneration**
   a. Q1a. Should drain be used in anterior cervical spine surgery?
   b. Q1b. Should drain be used in posterior cervical spine surgery?
2. Domain: **Thoracolumbar Degeneration**
   a. Q2a. Should drain be used in single-level lumbar spine surgery?
   b. Q2b. Should drain be used in multilevel thoracolumbar spine surgery?
3. Domain: **Deformity**
   a. Q3a. Should drain be used in spinal deformity correction surgery?
4. Domain: **Trauma**
   a. Q4a. Should drain be used in spinal trauma stabilisation surgery?
5. Domain: **Tumour**
   a. Q5a. Should drain be used in intradural spinal cord tumour excision surgery?
   b. Q5b. Should drain be used in extradural tumour excision surgery?

Fig. 1 Domains of drain use in spine surgery



Inclusion criteria

Any study meeting the following PICOS criteria were included for analysis.

Population	Patients undergoing spine surgery
Intervention	Wound drain
Comparator	No drain
Outcomes	SSI, haematoma, total blood loss, total transfusions, wound soakage, seroma formation, wound dehiscence, reoperation rate, length of hospital stay and neurological injury
Study Design	Both prospective and retrospective studies

Exclusion criteria

Studies were excluded if they had the following characteristics:

1. Case series and studies without comparator group.
2. Spine surgeries performed for infective spinal conditions.
3. No subgroup analysis if the main intervention in the study is not the usage of wound drain.
4. No defined patient characteristics including pathology addressed and surgery performed.

Search strategy

Two reviewers performed an independent electronic literature search in the following databases: PubMed, Embase, and the Cochrane Library up to April 2020. No language or date restrictions were applied. An individual search was made for each domain. Keywords used for the search were as follows: "Wound drain", "Suction drainage", "Drain", "Spine Surgery", "Spine", "SSI", "Surgical Site Infection", "Haematoma". These search terms were then subjected to a targeted cross-search for an individual domain. For example: "Cervical Vertebrae", "Stenosis", "Degeneration", "Anterior", "ACDF", "Spinal Fusion", "Posterior" for Cervical Degeneration domain. The reference list of the selected articles was also searched to identify studies not identified in the primary search. All the articles were analysed as per the inclusion and exclusion criteria, and the eligible studies were included for meta-analysis. The discrepancy between the authors was resolved through discussion until a consensus was obtained. A detailed study selection flow diagram is given in Fig. 2.

Data extraction

Two reviewers retrieved independently relevant data from articles included for analysis into an electronic spreadsheet (Microsoft Excel, Redmond, WA, USA) which had the necessary data fields created as a priori. Following data were extracted:

1. **Study characteristics:** Year of publication, authors, title, study design, domain category, number of patients enrolled in total, and between groups.
2. **Baseline characteristics:** mean age, underlying diagnosis/condition addressed, number of levels treated, approach utilised, surgery performed.
3. **Primary Outcomes:** Overall rate of SSI and haematoma formation.

   Secondary Outcomes: total blood loss, total transfusions, wound soakage, seroma formation, wound dehiscence, reoperation rate, length of hospital stay, and neurological injury.

Risk of bias

The methodological quality of the included studies was assessed independently by two reviewers using The Cochrane Collaboration's RoB 2 tool for Randomised Controlled Trials (RCTs) and ROBINS-I tool for non-randomised studies which has five and seven domains of bias assessment respectively [12, 13].

Evidence table

Synthesis and assessment of the quality of the derived evidence were based on the GRADE approach. From the risk of bias assessments and evidence tables, GRADE tables were produced using an online tool GradePro GDT [14] to evaluate the overall quality of the evidence of various outcomes to address the individual key question. Outcomes were graded according to GRADE as "High", "Moderate", "Low" to "Very Low" as shown in Table 1. Evidence summaries were made in plain language for every key question to reinforce the efficacy of the intervention based on the quality of the evidence.

Statistical analysis

Evidence table was constructed from each included study according to the key question it answered. Meta-analysis was

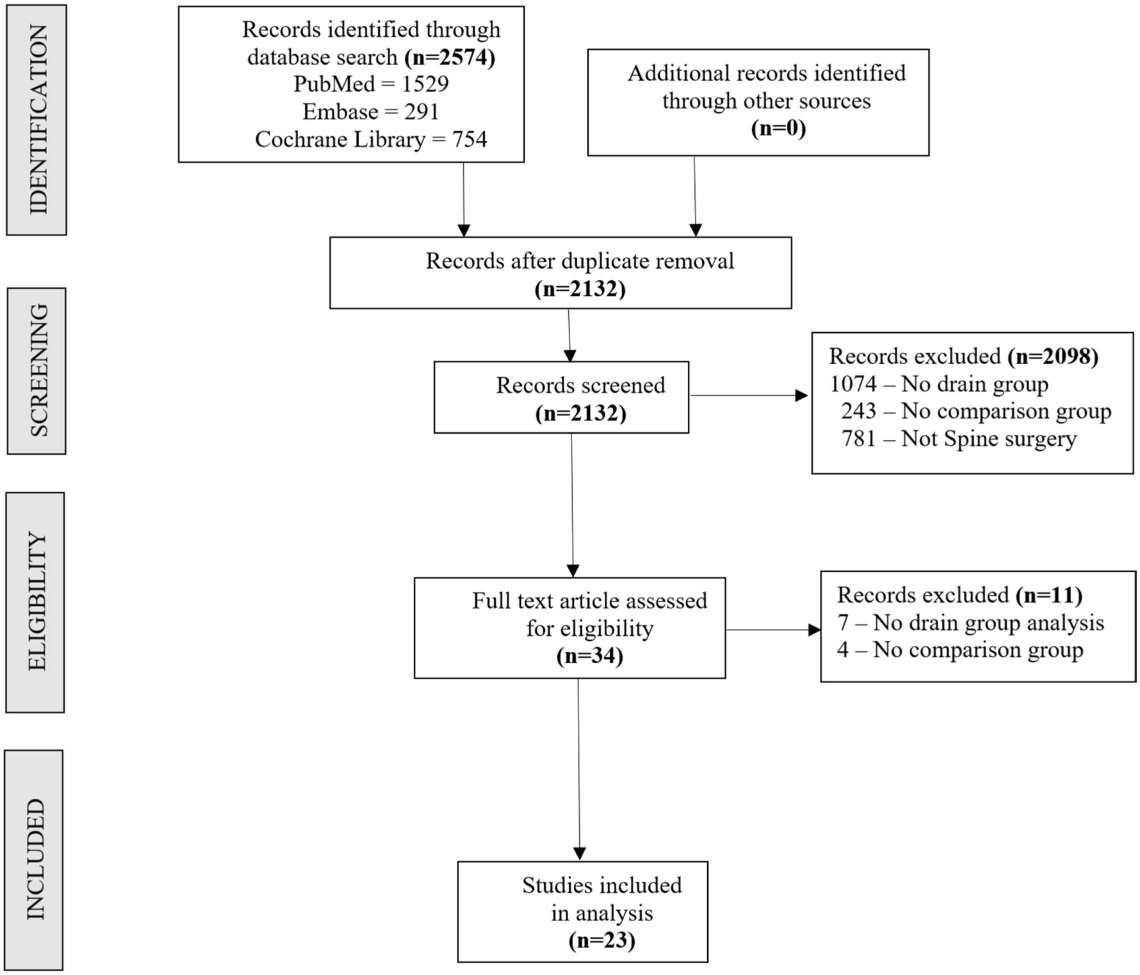


Fig. 2 PRISMA flow diagram of inclusion of the studies for analysis

Table 1 GRADE working group grades of evidence

Grade of evidence	Confidence of effect estimate	Inference
High certainty	Very confident in the effect estimate	The true effect lies close to that of the estimate of the effect
Moderate certainty	Moderately confident in the effect estimate	The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty	Confidence in the effect estimate is limited	The true effect may be substantially different from the estimate of the effect
Very low certainty	Very little confidence in the effect estimate	The true effect is likely to be substantially different from the estimate of effect

performed using Meta Essentials [15]. We used Risk Difference (RD) with 95% confidence intervals as our summary statistic with a random-effects model so that a straightforward comparison of the risks and benefits due to the intervention is studied. A p value < 0.05 was considered statistically significant. Appropriate nonparametric analysis like Fisher's exact test was performed when required from quantitative data of individual studies.

Results

Search results

Electronic database search resulted in 2574 articles which after initial screening for duplicate removal gave a total of 2132 articles. Title and abstract screening were done in those 2132 articles and 2098 of them were excluded. Thirty-four articles qualified for full-text review of which

11 were excluded. Finally, 23 studies including 9 RCTs [5, 8, 16–22], 4 Prospective studies [23–26], and 10 Retrospective studies [6, 7, 27–34] with a total of 5294 patients (Drain group/No Drain group = 3269/2025) were included in our analysis. PRISMA flow diagram of study selection is given in Fig. 2. The general characteristics of the studies included in our review are given in Table 2.

Quality assessment

The methodological quality of the included randomised and non-randomised studies was given in Figs. 3 and 4, respectively.

Domains of use of drains in spine surgery:

Five domains of use of drains in spine surgery have been conceptualised as shown in Fig. 1. It includes 1. Cervical Degeneration domain 2. Thoracolumbar Degeneration domain 3. Deformity domain 4. Trauma domain 5. Tumour domain

1. Domain: Cervical Degeneration

Q1a. Should drain be used in anterior cervical spine surgery?

We analysed the available evidence in the literature which compared anterior cervical spine surgeries for degenerative conditions like cervical degenerative disc disease done with and without the use of wound drains. The evidence for this comparison was derived from 2 studies [17, 29].

Kogure et al. [17] did an RCT to evaluate the role of indwelling drains in single-level anterior cervical fusion in 43 patients with a moderate risk of bias while Poorman et al. [29] in their retrospective cohort study evaluated the role of drains in Anterior Cervical Decompression and Fusion (ACDF) surgeries for single-level fusion from 81 patients with a low risk of bias. High-quality evidence from meta-analysis of two studies [17, 29] ($N = 124$) demonstrated that drain does not prevent haematoma formation while moderate-quality evidence from 1 study [29] showed that drain usage resulted in a significant increase in total blood loss and length of hospital stay. Low-quality evidence from one study [29] suggested drain may not prevent surgical site infection.

GRADE Summary of Findings table along with GRADE Certainty of evidence for the use of drains in anterior surgeries for cervical degenerative disorders are shown in Table 3.

Evidence summary: [High-quality evidence] In the setting of anterior cervical spine surgery utilisation of drain does not prevent haematoma formation and does not provide any additional benefit to the patient. There is insufficient evidence to support the use of wound drain for anterior cervical spine surgeries. However, well-powered high-quality RCTs are required to arrive at a definitive conclusion in this surgical scenario.

Q1b. Should Drain be used in posterior cervical spine surgery?

Literature analysis for studies that compared posterior cervical spine surgeries for degenerative conditions like spondylo-myelopathy done with and without the use of wound drains did not result in any prospective studies. Only one large retrospective cohort study by Herrick et al. [30] with 1799 participants elaborated on the role of the drain in posterior cervical spine surgeries.

This large retrospective study demonstrated high-quality evidence that utilisation of drain significantly increases the total blood loss from the patients undergoing posterior cervical spine surgery. Moderate-quality evidence showing no significant reduction in reoperation rate with the use of drains in posterior cervical spine surgeries. Moreover, the study gave low-quality evidence regarding the SSI prevention, haematoma formation, wound dehiscence, and length of hospital stay between the two groups demonstrating no added benefit from use of drain. Distribution of patients with a history of previous cervical spine surgery and type 2 diabetes were the confounding variables present among the two groups compared which reduced the quality of the evidence synthesised out of the study.

GRADE summary of findings table along with GRADE Certainty of evidence for the use of drains in posterior surgeries for cervical degenerative disorders are shown in Table 4.

Evidence summary: [High-quality evidence] In the setting of posterior cervical spine surgery for degenerative conditions of spine utilisation of drain increases the total blood loss and does not provide any additional benefit to the patient. There is insufficient evidence to support the use of wound drain for anterior cervical spine surgeries. However, well-powered high-quality RCTs are required to arrive at a definitive conclusion in this surgical scenario.

2. Domain: Thoracolumbar Degeneration

Q2a. Should drain be used in single-level lumbar spine surgery?

We analysed the literature for studies comparing the use of drains in surgeries for single-level lumbar degenerative disorders. A total of 8 studies including 4 RCT [5, 18, 20, 21], 2 prospective studies [25, 26], and 2 retrospective cohort studies [6, 31] investigated the utility of drain in this scenario with a total of 1190 patients, all of low or moderate risk of bias.

There was high-quality evidence that drain usage in single-level lumbar spine surgery did not reduce the risk of surgical site infection. The above evidence was obtained from a meta-analysis involving 5 studies [6, 18, 20, 21, 26]

Table 2 Characteristics of the included studies; $N=24$

Sl. no.	Author (year)	Study type	Population	Study group		Diagnosis	Surgery type	Domain
				Drain	No drain			
1	Ovadia et al. [16]	RCT	$N=100$ Age: 15.7 years % Male: 73	48	52	Adolescent idiopathic scoliosis	Deformity correction	Deformity
2	Kogure et al. [17]	RCT	$N=43$ Age: 57.8 years % Male: 56.5	23	20	Degenerative cervical spondylosis	Decompression and fusion	Cervical Degeneration
3	Brazolino et al. [18]	RCT	$N=60$ Age: 53.3 years % Male: NR	30	30	Degenerative lumbar stenosis	Decompression and fusion	Thoracolumbar degeneration
4	Brown et al. [8]	RCT	$N=83$ Age: 67.4 years % Male: NR	42	41	Degenerative lumbar stenosis	Decompression and fusion	Thoracolumbar degeneration
5	Gubin et al. [19]	RCT	$N=155$ Age: 48.4 years % Male: 41.2	80	75	Degenerative lumbar stenosis, trauma	Decompression and fusion, stabilisation	Thoracolumbar degeneration and trauma
6	Payne et al. [20]	RCT	$N=200$ Age: NR % Male: NR	103	97	Degenerative lumbar stenosis	Decompression	Thoracolumbar degeneration
7	Hung et al. [21]	RCT	$N=56$ Age: 63.2 years % Male: 35.7	28	28	Grade 1 spondylolisthesis, degenerative disk disease	Decompression and fusion	Thoracolumbar degeneration
8	Mirzai et al. [5]	RCT	$N=50$ Age: 47 years % Male: 72.7	22	28	Lumbar disc disease	Discectomy and decompression	Thoracolumbar degeneration
9	Kumar et al. [22]	RCT	$N=110$ Age: 35.6 years % Male: 80.7	52	58	Trauma	Short-segment fixation and fusion	Trauma
10	Blank et al. [23]	Prospective Study	$N=30$ Age: 14.4 years % Male: NR	18	12	Adolescent idiopathic scoliosis	Deformity correction	Deformity
11	Gubin et al. [24]	Prospective study	$N=85$ Age: 53.3 years % Male: 48.7	41	44	Degenerative Lumbar stenosis	Decompression and fusion	Thoracolumbar degeneration
11	Gubin et al. [24]	Prospective Study	$N=36$ Age: 37.8 years % Male: 15	20	16	Multilevel spinal deformity	Deformity correction	Deformity
12	Kotil et al. [25]	Prospective study	$N=115$ Age: 42.3 years % Male: 46.6	60	55	Lumbar disc disease	Discectomy and decompression	Thoracolumbar degeneration
13	Sen et al. [26]	Prospective study	$N=79$ Age: NR % Male: NR	41	38	Lumbar disc disease	Discectomy and decompression	Thoracolumbar degeneration
14	Kochai et al. [27]	Retrospective cohort study	$N=52$ Age: 15 years % Male: 46.4	28	24	Adolescent idiopathic scoliosis	Deformity correction	Deformity
15	Diab et al. [28]	Retrospective cohort study	$N=500$ Age: 15.7 years % Male: 62	324	176	Adolescent idiopathic scoliosis	Deformity correction	Deformity
16	Poorman et al. [29]	Retrospective cohort study	$N=81$ Age: 46.4 years % Male: 46.1	39	42	Cervical radiculopathy/myelopathy	Decompression and fusion	Cervical degeneration
17	Herrick et al. [30]	Retrospective cohort study	$N=1799$ Age: 63.6 years % Male: 60.6	1180	619	Degenerative cervical stenosis	Decompression and instrumentation	Cervical degeneration

Table 2 (continued)

Sl. no.	Author (year)	Study type	Population	Study group		Diagnosis	Surgery type	Domain
				Drain	No drain			
18	Choi et al. [6]	Retrospective cohort study	$N=70$ Age: 49.9 years % Male: 50	42	28	Degenerative lumbar stenosis	Decompression	Thoracolumbar degeneration
19	Kanayama et al. [31]	Retrospective cohort study	$N=560$ Age: 44 years % Male: 63.7	298	262	Degenerative lumbar stenosis	Decompression	Thoracolumbar degeneration
20	Adogwa et al. [7]	Retrospective cohort study	$N=139$ Age: 64.9 years % Male: 42.2	116	23	Degenerative thoracolumbar stenosis	Decompression and fusion	Thoracolumbar degeneration
21	Walsh et al. [32]	Retrospective cohort study	$N=320$ Age: NR % Male: NR	278	42	Degen thoracolumbar stenosis	Decompression and fusion	Thoracolumbar degeneration
22	Walid et al. [33]	Retrospective cohort study	$N=402$ Age: NR % Male: NR	281	121	Degenerative lumbar stenosis and spondylolisthesis	Decompression and fusion	Thoracolumbar degeneration
23	Sohn et al. [34]	Retrospective cohort study	$N=169$ Age: 46 years % Male: 52	75	94	Spinal cord tumours	Laminectomy and durotomy and tumour excision	Tumours

NR not reported, *RCT* randomised controlled trial

($N=465$). There was also high-quality evidence that utilisation of drain did not reduce the risk of neurological deterioration post-operatively from meta-analysis of 3 studies [20, 25, 31] ($N=875$). High-quality evidence arrived from the meta-analysis of 4 studies [18, 20, 25, 31] ($N=935$) that utilisation of drain did not reduce the reoperation rate.

Low-quality evidence was noted that drain did not prevent haematoma formation in lumbar spine surgeries involving a single level. This was arrived from a meta-analysis of 3 studies [5, 20, 25, 31] ($N=925$). There was a moderate quality of evidence from the meta-analysis of 4 studies [6, 20, 21, 26] ($N=405$). That wound drains might increase the length of hospital stay. There is also moderate-quality evidence from a meta-analysis of 4 studies [21, 25, 26, 31] ($N=810$). That wound drains do not increase the total blood loss when used for single-level lumbar spine surgeries.

GRADE summary of findings table along with GRADE Certainty of evidence for the use of drains in single-level lumbar spine surgeries for lumbar degenerative disorders are shown in Table 5.

Evidence summary: [High-quality evidence] In the setting of single-level lumbar spine surgery, utilisation of drain did not reduce the risk of surgical site infection, reoperation rate, or post-operative neurological deterioration and did not provide any additional benefit to the patient despite increasing the length of hospital stay. There is insufficient evidence to support the use of wound drain in this surgical scenario.

Q2b. Should drain be used in multilevel thoracolumbar spine surgery?

Literature analysis for studies comparing the use of drains in multilevel thoracolumbar spine surgeries was done. A total of 6 studies including 2 RCTs [8, 19], 1 prospective study [24], and 3 retrospective cohort studies [7, 32, 33] compared the use of drains for multilevel degenerative disorders of the spine. They had low to moderate risk of bias and hence they were included for analysis.

High-quality evidence from the meta-analysis of 6 studies [7, 8, 19, 24, 32, 33] ($N=1148$) demonstrated that in multilevel thoracolumbar spine surgeries for degenerative conditions like multilevel spinal canal stenosis or disc disease, utilisation of drain does not significantly reduce the risk of surgical site infection. Moreover, moderate-quality evidence has shown that utilisation of drain resulted in a significant increase in total blood loss. The above result was obtained from meta-analysis of 4 studies [7, 8, 19, 24] ($N=341$). There was also high-quality evidence that utilisation of drain does not reduce the reoperation rate as per meta-analysis of 3 studies [7, 8, 33] ($N=624$). Moderate-quality evidence exists to show that drain usage does not reduce the saturated wound soakage in the post-operative period obtained by a meta-analysis of 2 studies [7, 8] ($N=222$). Low-quality evidence was obtained from meta-analysis of 4 studies [7, 8, 19, 24] ($N=341$) that drain may result in little to no difference in length of hospital stay upon its usage.

GRADE summary of findings table along with GRADE Certainty of evidence for the use of drains in multilevel

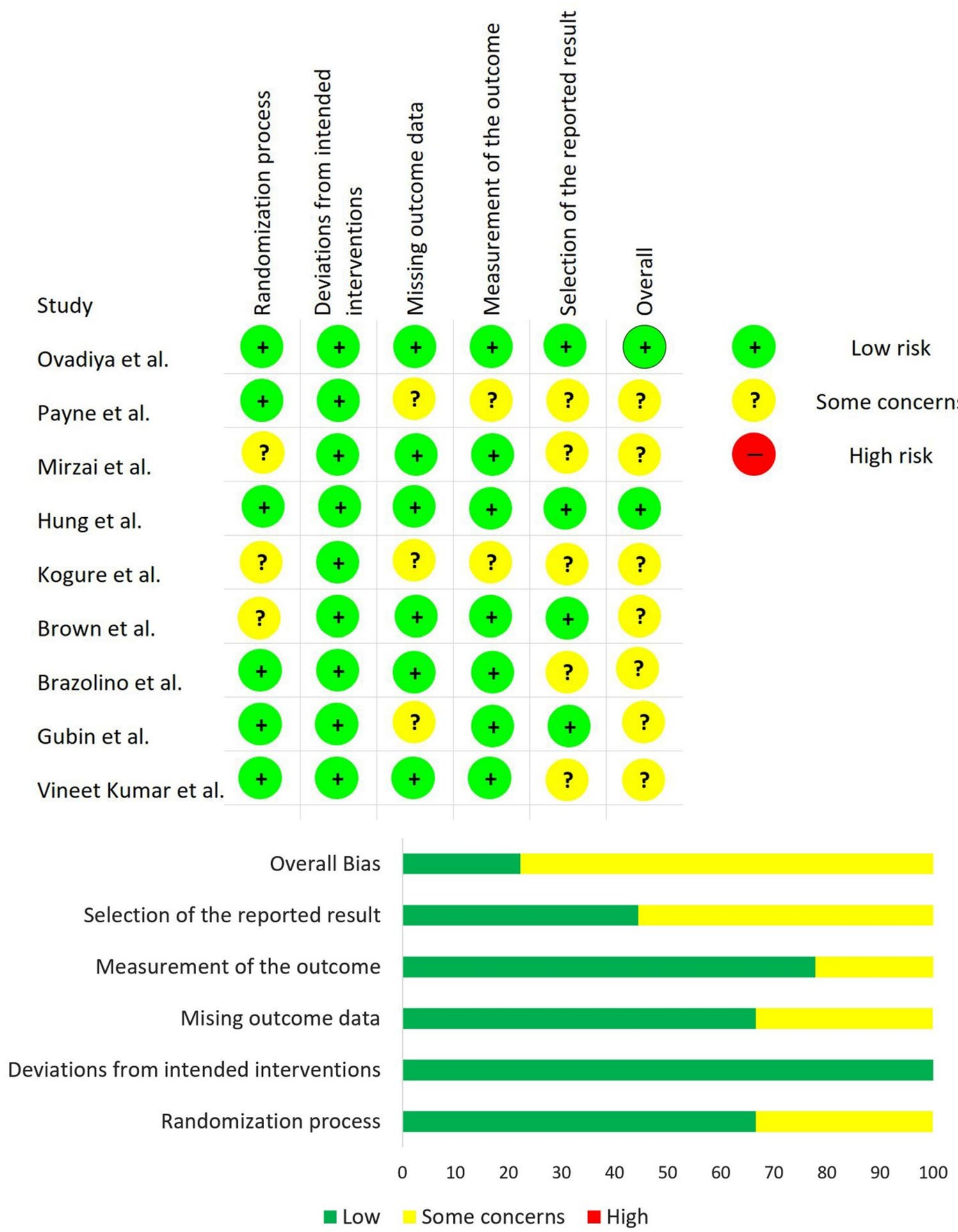


Fig. 3 Risk of bias evaluation of the RCTs using the ROB 2 tool

thoracolumbar spine surgeries for degenerative disorders are shown in Table 6.

Evidence summary: [High-quality evidence] In the setting of multilevel thoracolumbar spine surgery, utilisation of drain did not reduce the risk of surgical site infection and did not provide any additional benefit to the patient despite increasing the total blood loss. There is insufficient evidence to support the use of wound drain in this surgical scenario.

Domain: deformity

Q3a. Should drain be used in spinal deformity correction surgery?

We analysed the literature for studies comparing the use of drains in deformity correction surgeries of the spine. A total of 5 studies including 1 RCT, [16] 2 prospective study [23, 24], and 2 retrospective cohort studies [27, 28] investigated the utility of drain in spinal deformity correction surgery with a total of 767 patients, all of low or moderate risk of bias.

There was a high quality of evidence regarding the SSI prevention and reoperation rate between the two groups demonstrating no added benefit from the use of drain to reduce either SSI or reoperation rate. This was based on a meta-analysis of five studies [16, 23, 24, 27, 28] ($N=767$). Although all the studies addressed spinal deformity correction surgery, the total levels involving involved varied among the included studies. Moderate-quality evidence from a meta-analysis of two studies [23, 27] ($N=82$) showed that

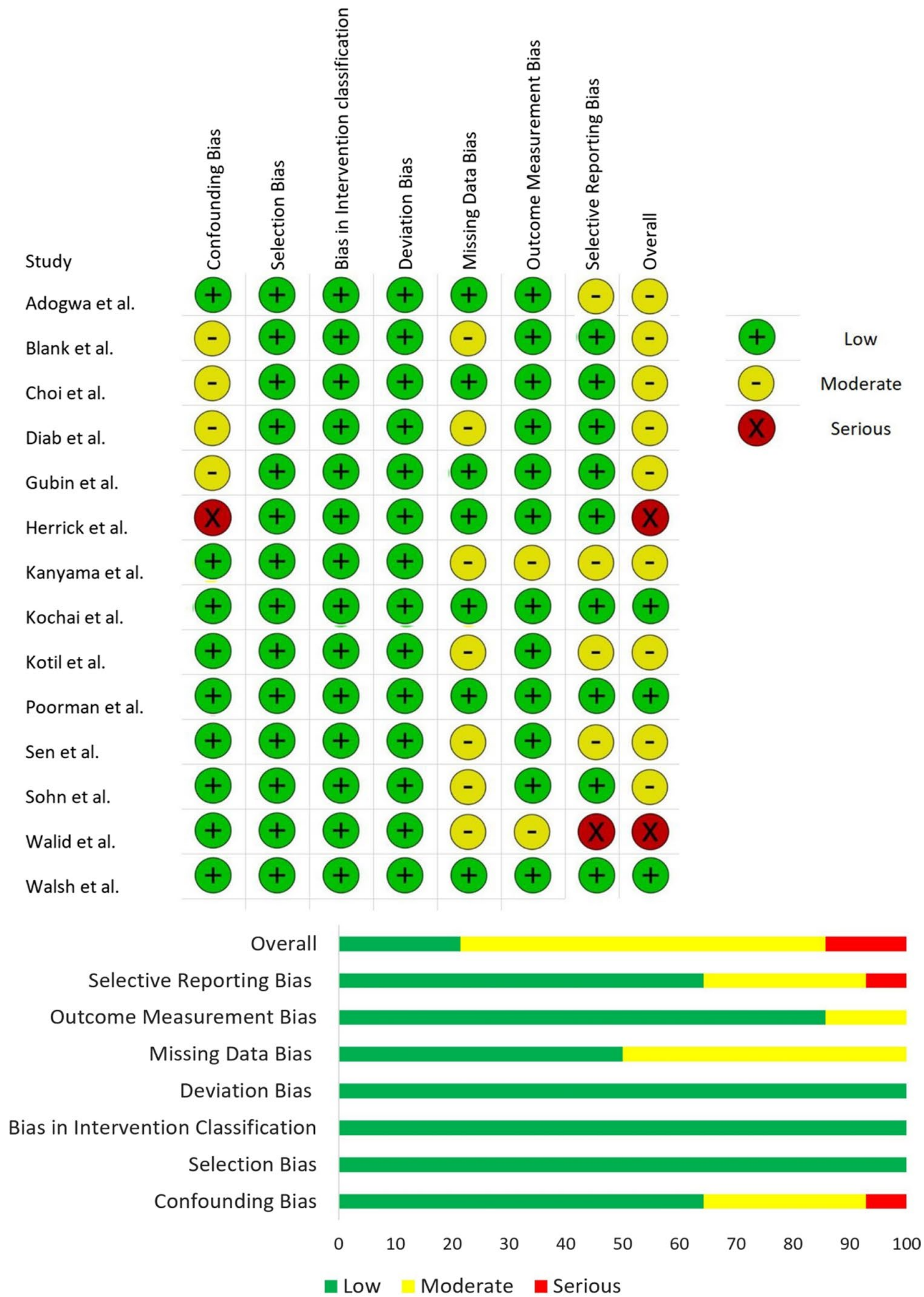


Fig. 4 Risk of bias evaluation of the non-randomised studies using the ROBINS-I tool

drain usage did not reduce the number of saturated wound soakage during the immediate post-operative period.

Evidence was available from five studies concerning total blood loss [16, 23, 24, 27, 28]. Moderate-quality evidence from a meta-analysis of 4 studies($N=767$) suggested that drain usage may result in a significant increase in total blood loss. However low-quality evidence from a meta-analysis of five studies [[16, 23, 24, 27, 28] 16,23,24 27,28] ($N=767$) did not find a significant increase in transfusions between either group. Moderate-quality evidence from a meta-analysis of 3 studies [16, 24, 27] ($N=237$) suggested no significant reduction in length of hospital stay from the use of drains.

GRADE summary of findings table along with GRADE Certainty of evidence for the use of drains in spinal deformity correction surgeries are shown in Table 7.

Evidence summary: [High-quality evidence] In the setting of spinal deformity correction, utilisation of drain did

Table 3 Summary of findings table with GRADE certainty of evidence for key question 1a

Should drain be used in anterior cervical spine surgeries?

Patient or population: Patients undergoing anterior cervical spine surgery
Setting: Cervical Degeneration—Anterior
Intervention: Drain
Comparison: No Drain

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no drain	Risk difference with drain				
Surgical site infection (SSI)	2 per 100	0 per 100 (−0 to 0)	Risk difference 0.022 (−0.042 to 0.087)	81 (1 Cohort study)	⨁⨁◯◯ LOW[a]	Drain may not reduce surgical site infection
Haematoma formation	3 per 100	0 per 100 (−0 to 0)	Risk difference 0.005 (−0.041 to 0.050)	124 (1 RCT & 1 Cohort study)	⨁⨁⨁⨁ HIGH	Drain does not reduce haematoma formation
Total blood loss	The mean total blood loss was 29.1 ml	MD 33.6 ml more (13 more to 54 more)	–	81 (1 Cohort study)	⨁⨁⨁◯ MODERATE[a]	Drain likely results in an increase in total blood loss
Length of hospital stay	The mean length of hospital stay was 31.7 h	MD 7.2 h more (1.15 more to 13.24 more)	–	81 (1 Cohort study)	⨁⨁⨁◯ MODERATE[a]	Drain probably results in an increased length of hospital stay

CI confidence interval, *MD* mean difference

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI)

[a]Inconsistency could not be assessed as the outcome involves one study

not provide any additional benefit to the patient in reducing the risk of surgical site infection or reoperation rate. There is insufficient evidence to support the use of wound drain in this surgical scenario.

3. Domain: Trauma

Q4a. Should drain be used in spinal trauma stabilisation surgery?

Two RCTs [19, 22] evaluated the risk of surgical site infection and total blood loss with and without the use of drains in a trauma fixation surgery involving spine with 133 participants in total with a low risk of bias. In both the studies, patients with coagulopathy were excluded.

Vineeth Kumar et al. [22] investigated the parameters like haemoglobin drop, C-reactive protein levels, visual analog score for pain between the groups and did not find any significant difference among them. Moreover, both the groups did not differ in the length of hospital stay or SSI rate or clinically significant risk of haematoma formation or risk of neurological deterioration.

Whereas Gubin et al. [19] found significantly higher total blood loss and transfusion requirements in the drain group and significantly higher number and volume of postoperative aspirations in the no drain group. However, both groups did not vary in SSI rate or length of hospital stay. Since the evidence was from a restricted subset of the total population, the evidence was downgraded by one point due to the indirectness and lack of generalisability as per GRADE.

Moderate-quality evidence was synthesised from the meta-analysis of the two studies [19, 22] ($N=133$). The utilisation of drain did not reduce the risk of SSI or alter the length of hospital stay. Low-quality evidence from their meta-analysis showed that utilisation of drain for spinal trauma stabilisation surgeries did not result in a significant increase in total blood loss.

GRADE summary of findings table along with GRADE Certainty of evidence for the use of drains in spinal trauma stabilisation surgeries are shown in Table 8.

Evidence summary: [Moderate-quality evidence] In the setting of spinal trauma stabilisation surgeries, utilisation of drain did not reduce the risk of SSI or provide any additional benefit to the patient. There is insufficient evidence to support the use of wound drain in this surgical scenario.

4. Domain: Tumour

Q5a. Should drain be used in intradural spinal cord tumour excision surgery?

We searched the literature for studies that analysed the use of drain for intradural spine cord tumour excision

Table 4 Summary of findings table with GRADE certainty of evidence for key question 1b

Should Drain be used in posterior cervical spine surgery?

Patient or population: Patients undergoing posterior cervical spine surgery
Setting: Cervical Degeneration—Posterior
Intervention: Drain
Comparison: No Drain

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no drain	Risk difference with drain				
Surgical site infection (SSI)	3 per 100	0 per 100 (− 0 to 0)	Risk difference 0.010 (− 0.005 to 0.024)	1799 (1 Cohort study)	⨁⨁◯◯ LOW[a,b]	Drain may not reduce surgical site infection
Haematoma formation	0 per 100	− 0 per 100 (− 0 to 0)	Risk difference − 0.002 (− 0.009 to 0.005)	1799 (1 Cohort study)	⨁⨁◯◯ LOW[a,b]	Drain may not reduce haematoma formation
Total blood loss (TBL)	The mean total blood loss was 199.8 ml	MD 55.4 ml more (54.2 more to 56.5 more)	–	1799 (1 Cohort study)	⨁⨁⨁⨁ HIGH[a,b]	Drain may result in a significant increase in total blood loss
Reoperation rate	4 per 100	− 0 per 100 (− 0 to 0)	Risk difference − 0.002 (− 0.002 to 0.017)	1799 (1 Cohort study)	⨁⨁⨁◯ MODERATE[a,b]	Drain probably does not reduce reoperation rate
Wound dehiscence	1 per 100	− 0 per 100 (− 0 to 0)	Risk difference − 0.005 (− 0.014 to 0.003)	1799 (1 Cohort study)	⨁⨁◯◯ LOW[a,b]	Drain may not reduce wound dehiscence
Length of hospital stay	The mean length of hospital stay was 4 days	MD 0 days (2 fewer to 2 more)	–	1799 (1 Cohort study)	⨁⨁◯◯ LOW[a,b]	Drain may not increase/reduce length of hospital stay

CI confidence interval, *MD* mean difference

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI)

[a]History of type 2 diabetes and previous cervical spine surgery were the confounding variables

[b]Consistency could not be evaluated since the outcome involves one study

surgery. One large retrospective cohort study by Sohn et al. [34] investigated the prophylactic use of drains after excision of intradural primary spinal cord tumour to prevent the CSF leak related complications with 169 patients with a low risk of bias. They evaluated the post-operative MRI of the patients and found comparable fluid collection in both the groups which was consistent with CSF and it resolved uneventfully regardless of drain usage except for 2 patients in the drain group who required reoperation for wound-related complication. None of the members of either group had neurological deterioration. Both groups did not differ in the length of hospital stay.

GRADE summary of findings table along with GRADE Certainty of evidence for use of drains in intradural spinal cord tumour excision surgeries are shown in Table 9.

Evidence summary: [Moderate-quality evidence] In the setting of surgeries for intradural spinal cord tumour excision surgeries, prophylactic utilisation of drain did not provide additional benefit to the patient in preventing or managing CSF leak resulting from intradural tumour excision. There is insufficient evidence to support the use of wound drain in this surgical scenario.

Q5b. Should drain be used in extradural tumour excision surgery?

Evidence summary: No studies met the inclusion criteria to evaluate the utility of a wound drain in this surgical scenario.

Discussion

Surgical site infections in spine surgery cause devastating morbidity to the patient. Hence many pre-operative, intra-operative and post-operative measures were being investigated for their potential role in preventing the risk of SSI

Table 5 Summary of findings table with GRADE certainty of evidence for key question 2a

Should drain be used in single-level lumbar spine surgery?

Patient or population: Patients undergoing single-level lumbar spine surgery
Setting: Thoracolumbar Degeneration
Intervention: Drain
Comparison: No Drain

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no drain	Risk difference with drain				
Surgical site infection (SSI)	2 per 100	0 per 100 (−0 to 0)	Risk difference 0.004 (−0.021 to 0.029)	465 (5 studies)	⨁⨁⨁⨁ HIGH	Drain does not reduce surgical site infection
Haematoma formation	2 per 100	0 per 100 (−0 to 0)	Risk difference 0.015 (−0.008 to 0.037)	925 (4 studies)	⨁⨁◯◯ LOW[a,b]	Drain probably does not reduce haematoma formation
Total blood loss	The mean total blood loss was 182.6 ml	MD 1.76 ml higher (3.81 lower to 7.33 higher)	–	810 (4 studies)	⨁⨁⨁◯ MODERATE[a]	Drain probably does not increase total blood loss
Reoperation rate	0 per 1000	0 per 1000 (0 to 0)	Risk difference 0.003 (−0.002 to 0.008)	935 (4 studies)	⨁⨁⨁⨁ HIGH	Drain does not reduce reoperation rate
Neurological injury	0 per 100	0 per 100 (−0 to 0)	Risk difference 0.003 (−0.002 to 0.008)	875 (3 studies)	⨁⨁⨁⨁ HIGH	Drain does not reduce neurological Injury
Length of hospital stay	The mean length of hospital stay was 6.15 days	MD 6.09 days more (3.71 more to 8.48 more)	–	405 (4 studies)	⨁⨁⨁◯ MODERATE[a]	Drain probably increases length of hospital stay

CI confidence interval, MD mean difference

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI)

[a]Significant heterogeneity noted between the included studies for the outcome analysed

[b]Method of haematoma identification differed among the included studies

[35, 36]. Despite wound drain being a universal surgical measure followed to reduce the risk of SSI and haematoma formation in spine surgery, critical appraisal of the evidence supporting its use is needed to rationalise the usage.

In lumbar spine surgeries for single-level degenerative disorders, our study did not find any superiority from using wound drains either in preventing SSI or reducing haematoma formation or reoperation rate. Moreover, we found a significant increase in the length of hospital stay which could further contribute to increasing the risk of SSI. Our findings were concurrent with the review by Davidoff et al. [37] and Zijlmans et al. [38] who analysed the role of drains in non-complex lumbar surgeries. Since symptomatic epidural haematoma and infections are rare in such single-level procedures with minimal blood loss, use of drains may not be warranted in them. Although reduced epidural fibrosis and size of epidural haematoma was found in a few MRI studies upon utilisation of drain in lumbar surgeries [5, 26], clinical implications of their observation need to be verified in future by well-powered large RCTs. Our findings were consistent with the Cochrane review by Parker et al. [39].

While multilevel posterior spine surgeries involving cervical or thoracolumbar region is concerned, the extensive procedure with increased intra-operative blood loss makes the surgeons get inclined towards the use of drains to prevent reoperation for haematoma as recommended by Yao et al. [40]. Contrary to their result, we noted a significant increase in the total blood loss from the usage of drains compared to controls which could be prevented by mitigating their usage in this surgical scenario. Moreover, their usage did not reduce the risk of SSI, wound soakage rate or reoperation rate. Although meta-analysis by Liu et al. [41] noted a significant reduction in the saturated wound soakage by involving two underpowered studies with 113 subjects in total, our review involving four studies [7, 8, 23, 27] with larger sample size($N=304$) did not find a similar outcome to support their usage. Despite the extensiveness of the surgery, utilisation of drain did not confer any additional benefit but only increased the total blood loss in multilevel

Table 6 Summary of findings table with GRADE certainty of evidence for key question 2b

Should drain be used in multilevel thoracolumbar spine surgery?

Patient or population: Patients undergoing multilevel thoracolumbar spine surgery
Setting: Thoracolumbar Degeneration
Intervention: Drain
Comparison: No Drain

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no drain	Risk difference with drain				
Surgical site infection (SSI)	3 per 100	0 per 100 (−0 to 0)	Risk difference 0.007 (−0.015 to 0.028)	1148 (6 studies)	⨁⨁⨁⨁ HIGH[a]	Drain does not reduce surgical site infection
Total blood loss (TBL)	The mean total blood loss was 386.05 ml	MD 212.8 ml more (45.4 more to 380.1 more)	–	341 (4 studies)	⨁⨁⨁◯ MODERATE[b,c]	Drain likely results in increased total blood loss
Saturated wound soakage	27 per 100	4 per 100 (−1 to 9)	Risk difference 0.138 (−0.050 to 0.327)	222 (2 studies)	⨁⨁⨁◯ MODERATE[a]	Drain likely does not reduce saturated wound soakage
Reoperation Rate	2 per 100	0 per 100 (−0 to 0)	Risk difference 0.003 (−0.015 to 0.009)	624 (3 studies)	⨁⨁⨁⨁ HIGH	Drain does not reduce reoperation rate
Length of hospital stay	The mean length of hospital stay was 7.6 days	MD 0.7 days more (0.4 fewer to 1.9 more)	–	341 (4 studies)	⨁⨁◯◯ LOW[a,b]	Drain may result in little to no difference in length of hospital stay

CI confidence interval, *MD* mean difference

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI)

[a]Confounding bias noted in the included studies

[b]Significant heterogeneity noted among the studies included to analysed the outcome

[c]Wider confidence interval of the intervention group outcome

thoracolumbar surgery which was concurrent with the recommendation by F Waly et al. [3] in their review on the subject. The type of drain used may decide the volume of fluid collected [42]. However, of the 23 studies included in the analysis, one study [5] reported the use of gravity drain while 19 studies used suction drain and 3 studies did not mention the type of drain utilised; hence, we could not evaluate the effect of the drain type on the outcome measure such as blood loss.

Since anterior cervical surgical field is in close proximity to the vital structures which are more prone to the mass effect of post-operative haematoma drains are commonly used in this surgical scenario. However, from our study we found that drains not only failed to reduce the risk of haematoma formation or SSI but also caused an increased total blood loss and length of hospital stay upon utilisation. This was concurrent with the review findings of Patel et al. [43].

Although none of the reviews have addressed the use of drains in spinal trauma stabilisation, from the available evidence in the literature we found that drains did not reduce the risk of SSI and also resulted in an increased total blood loss and increased length of hospital stay when used in such surgical scenario.

While considering the scenario of intradural spine surgery, CSF leakage and collection may happen even after watertight dural closure [44]. Hence, if a suction drain is used to reduce post-operative haematoma and fluid collection, it may promote the CSF leakage due to suction effect. Although high-quality evidence is lacking on this subject, our review identified a retrospective cohort study [34] that investigated the role of a drain in this controversial scenario. The use of drain did not alter the amount of CSF collection but it resulted in increased reoperation rate and length of hospital stay compared to patients without a drain. Role of drain in the management of CSF leak following incidental durotomy following spinal surgery for degenerative conditions has not yet been clarified due to the lack of high-quality evidence to establish their utility. Although 4 of the included studies reported such events among both the groups analysed, utilisation of drain did not bring about any significant change to the outcome measures.

Table 7 Summary of findings table with GRADE certainty of evidence for key question 3a

Should drain be used in spinal deformity correction surgery?

Patient or population: Patients undergoing spinal deformity correction surgery
Setting: Deformity
Intervention: Drain
Comparison: No drain

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no drain	Risk difference with drain				
Surgical site infection (SSI)	4 per 100	0 per 100 (−0 to 0)	Risk difference 0.005 (−0.016 to 0.027)	767 (5 studies)	⊕⊕⊕⊕ HIGH	Drain usage does not reduce surgical site infections
Reoperation rate	3 per 100	0 per 100 (−0 to 0)	Risk difference −0.003 (−0.018 to 0.012)	767 (5 studies)	⊕⊕⊕⊕ HIGH	Drain usage does not reduce reoperation rate
Saturated wound soakage	17 per 100	1 per 100 (−4 to 5)	Risk difference 0.039 (−0.238 to 0.315)	82 (2 studies)	⊕⊕⊕◯ MODERATE[a]	Drain probably does not reduce saturated wound soakage
Total blood loss (TBL)	The mean total blood loss was 800.2 ml	MD 792 ml more (304.9 more to 1279.1 more)	–	767 (5 studies)	⊕⊕⊕◯ MODERATE[a,b,c]	Drain likely results in a large increase in total blood loss
Transfusions	The mean transfusions was 0.8 units	MD 0.883 units more (0.201 fewer to 1.967 more)	–	767 (5 studies)	⊕⊕◯◯ LOW[a,b]	Drain usage may not result in increased transfusions
Length of hospital stay	The mean length of hospital stay was 5.9 days	MD 0.3 days fewer (1.63 fewer to 0.89 more)	–	237 (2 studies)	⊕⊕⊕◯ MODERATE[b]	Drain probably does not reduce length of hospital stay

CI confidence interval, *MD* mean difference

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI)

[a]Number of levels operated varied among the included studies

[b]Significant heterogeneity noted among the included studies for the outcome analysed

[c]Wide range of confidence interval of the mean difference noted in the drain group

While considering all these surgical domains individually or altogether, utilisation of wound drains in spine surgery did not result in significant risk reduction in SSI or haematoma formation as shown in Figs. 5, 6 thereby nullifying the reasons for their continued usage. Hence, their use is no longer recommended as a routine surgical practice unless their usage is supported by high-quality evidence in the future. The advantages of not using a drain not only includes a reduced hospital stay but also an improved comfort with less anxiety caused by removal of drains. In cost–benefit analysis, considering over 88,000 lumbar decompression surgeries were performed in the United States in 2010 [45], amounts to over 2.6 M$ would be spent for the use of drains alone without any additional benefit to the patient.

Strengths and limitations

While similar findings could be observed across multiple independent analyses on the subject, the current review is notable for addressing their limitations. First, we made a domain-specific assessment of the role of drains in various surgical scenarios. This was a major limitation of previous studies [46] which assessed their role across surgeries from single-level fusion to extensive deformity corrections altogether. Hence, their role in the individual surgical scenario could be overshadowed by others, thereby altering the final results of the study. Second, we included studies in which patients with and without wound drain could be clearly identified and compared. Many previous studies [37, 38] did not include studies with both groups clearly made out and failed to accurately estimate the intervention effect. Since drains are mostly used in spine surgeries to prevent rare events like epidural haematoma, considering small, single centre studies or systematic reviews involving such studies to assess

Table 8 Summary of findings table with GRADE certainty of evidence for key question 4a

Should drain be used in spinal trauma stabilisation surgery?

Patient or population: Patients undergoing spinal stabilisation surgery
Setting: Trauma
Intervention: Drain
Comparison: No drain

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no drain	Risk difference with drain				
Surgical site infection (SSI)	3 per 100	0 per 100 (− 0 to 0)	Risk difference 0.019 (− 0.041 to 0.079)	133 (2 RCTs)	⨁⨁⨁◯ MODERATE[a]	Drain usage did not result in a significant reduction of surgical site infection
Total blood loss (TBL)	The mean total blood loss was 271.6 ml	MD 125.7 ml more (247.1 fewer to 498.5 more)	–	133 (2 RCTs)	⨁⨁◯◯ LOW[a,b]	Drain usage results in little to no difference in total blood loss
Length of hospital stay	The mean length of hospital stay was 10.6 days	MD 0.378 days higher (0.6 higher to 1.3 higher)	–	133 (2 RCTs)	⨁⨁⨁◯ MODERATE[a]	Usage of drain did not significantly increase the length of hospital stay

CI confidence interval, *MD* mean difference

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI)

[a]Traumatic spine surgeries were included only as a subset of the total population

[b]Significant heterogeneity found between the included studies

Table 9 Summary of findings table with GRADE certainty of evidence for key question 5a

Should drain be used in intradural spinal cord tumour excision surgery?

Patient or population: Patients undergoing intradural spinal cord tumour excision surgery
Setting: Tumour
Intervention: Drain
Comparison: No Drain

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no drain	Risk difference with drain				
CSF collection	9 per 100	0 per 100 (− 1 to 1)	Risk difference 0.018 (− 0.060 to 0.090)	169 (1 Cohort study)	⨁⨁⨁◯ MODERATE[a]	Drain probably does not reduce CSF collection
Reoperation Rate	0 per 100	0 per 100 (0 to 0)	Risk difference 0.028 (− 0.070 to 0.015)	169 (1 Cohort study)	⨁⨁⨁◯ MODERATE[a]	Drain probably does not reduce reoperation rate
Length of hospital stay	The mean length of hospital stay was 9.35 days	MD 0.1 days higher (1.52 lower to 1.72 higher)	–	169 (1 Cohort study)	⨁⨁⨁◯ MODERATE[a]	Drain probably does not reduce length of hospital stay

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI)

[a]Single only one study is included consistency of results could not be assessed

CI: Confidence interval; **MD:** Mean difference

Study name / Subgroup name	Odds Ratio	CI Lower limit	CI Upper limit	Weight	p-Value	I²
K Kogure et al.	1.15	0.02	67.94	2.68%		
CE Poorman et al.	2.86	0.11	75.86	4.04%		
DB Herrick et al.	1.62	0.83	3.18	93.28%		
Cervical	**1.64**	**1.12**	**2.41**	**28.79%**	**0.948**	**0.00%**
D Ovadia et al.	4.80	0.22	106.56	7.90%		
A Kochai et al.	0.92	0.21	4.04	35.47%		
A Gubin et al.	0.93	0.05	16.02	9.41%		
J Blank et al.	0.73	0.05	10.09	11.66%		
M Diab et al.	1.11	0.26	4.70	35.55%		
Deformity	**1.09**	**0.58**	**2.05**	**24.69%**	**0.950**	**0.00%**
O Sen et al.	1.08	0.02	59.24	9.56%		
HS Choi et al.	8.02	0.35	183.38	15.73%		
PI Hung et al.	0.48	0.04	5.96	24.58%		
D Payne et al.	0.53	0.05	5.98	25.47%		
M Brazolino et al.	0.48	0.04	5.92	24.66%		
Lumbar	**0.83**	**0.20**	**3.35**	**14.84%**	**0.840**	**0.00%**
O Adogwa et al.	0.69	0.03	14.18	12.18%		
MD Brown et al.	1.02	0.02	56.04	8.13%		
A Gubin et al.	0.88	0.05	15.25	13.29%		
AV Gubin et al.	1.24	0.02	76.13	8.03%		
MS Walid et al.	0.69	0.19	2.56	27.12%		
TL Walsh et al.	0.11	0.04	0.29	31.25%		
Thoracolumbar	**0.43**	**0.15**	**1.29**	**17.38%**	**0.020**	**62.73%**
A Gubin et al.	1.10	0.05	23.69	30.04%		
Vineet Kumar	0.44	0.04	5.12	42.81%		
Sohn et al.	0.16	0.01	3.36	27.15%		
Trauma/Tumour	**0.44**	**0.05**	**4.13**	**14.30%**	**0.477**	**0.00%**
Combined effect size	**0.88**	**0.51**	**1.53**		**0.000**	**61.14%**

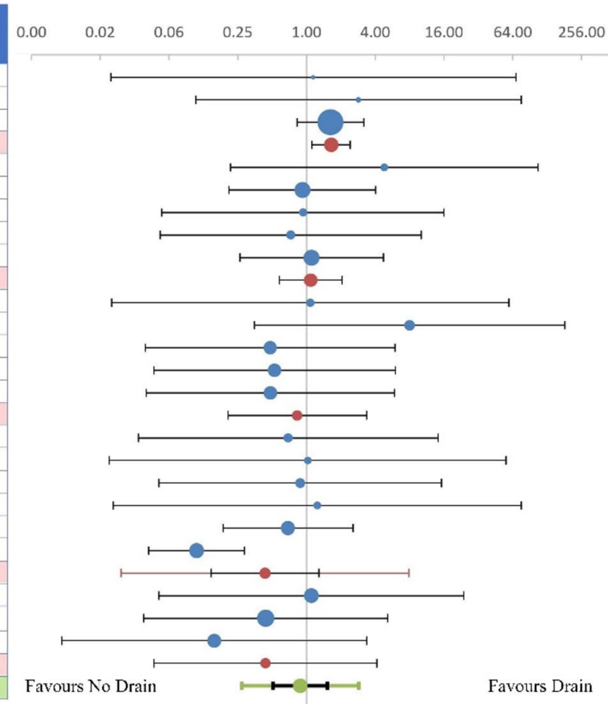


Fig. 5 Forest plot comparing the use of drains in the prevention of surgical site infection along with subgroup analysis in various surgical scenarios

Study name / Subgroup name	Odds Ratio	CI Lower limit	CI Upper limit	Weight	p-Value	I²
CE Poorman et al.	0.93	0.02	50.97	6.89%		
K Kogure et al.	0.53	0.08	3.42	32.53%		
DB Herrick et al.	0.71	0.19	2.70	60.58%		
Cervical	**0.66**	**0.40**	**1.10**	**64.46%**	**0.937**	**0.00%**
A Kochai et al.	1.16	0.02	66.97	10.49%		
D Payne et al.	1.06	0.02	55.34	10.64%		
K Kotil et al.	5.65	0.26	124.43	17.56%		
Vineet Kumar et al.	0.90	0.02	48.11	10.59%		
O Adogwa et al.	1.64	0.06	42.67	15.73%		
M Kanayama et al.	0.23	0.01	4.76	17.76%		
H Mirzai et al.	4.25	0.18	100.67	17.23%		
Thoracolumbar	**1.46**	**0.49**	**4.32**	**35.54%**	**0.729**	**0.00%**
Combined effect size	**0.87**	**0.37**	**2.07**		**0.926**	**0.00%**

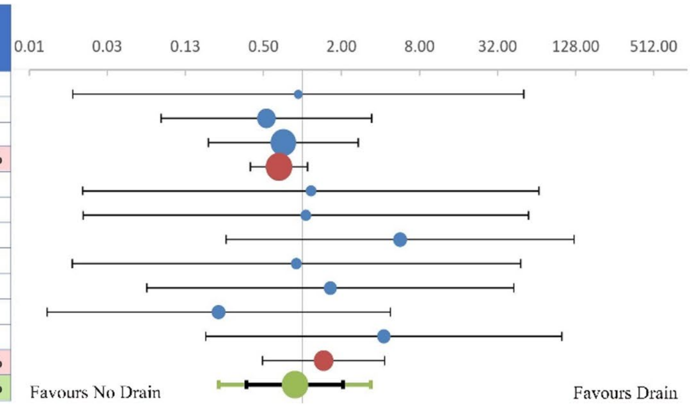


Fig. 6 Forest plot comparing the use of drains in the prevention of haematoma formation along with subgroup analysis in various surgical levels

their role in preventing such rare occurrence cannot be considered optimal. Therefore, we included several retrospective cohort studies in this review which had sample sizes of greater magnitude to demonstrate a statistically significant effect on the outcome with and without their usage.

Our review has several limitations. First, the included studies are heterogenous in their study designs although this was a purposeful result of broad inclusion criteria to evaluate uncommon complications like an epidural haematoma. Second, the included studies did not have a universal drain fixation and removal protocol which might have altered the outcome measures. Third, data on the exclusion of patients with coagulopathy was not available in all of the included studies. Finally, the study is limited by the small number of studies in specific domains with inherent methodological flaws. For example, no high-quality large prospective studies were found in domains like cervical degeneration, trauma or tumour surgeries to give high-quality evidence on the subject. This has pointed towards the gap in the knowledge that currently exists which might be fulfilled by studies in the future. Although concrete evidences were not available to support the use of drain, considering the limitations of our study, discretion of the surgeon is needed for the use of drain in circumstances such as diffuse intra-operative bleeding, morbid obesity and patients requiring anticoagulation therapy which is beyond the scope of this review.

Conclusion

Evidence from this review suggests that the routine use of a drain in various domains of spine surgery does not reduce the risk of SSI and their absence did not increase the risk of haematoma formation. The current best evidence is presented with its limitations. High-quality studies to address their use in spine surgeries in cervical, trauma, and tumour domains are required to further strengthen the evidence synthesised from the available literature.

Compliance with ethical standards

Conflict of interest None of the authors has any potential conflict of interest.

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