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Research Paper

Comparison of negative pressure wound therapy against normal dressing after vascular surgeries for inguinal wounds: A systematic review and meta-analysis

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HIGHLIGHTS

- Negative Pressure Wound Therapy is an emerging therapeutic technique that applies sub-atmospheric pressure to a wound.
- NPWT group had lesser odds of developing surgical site infection compared to normal dressing.
- Patients receiving NPWT had lesser odds of needing surgical wound revision.
- No significant difference was observed in duration of hospital stay, cost of care, or wound healing time.

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ABSTRACT

Background: Negative Pressure Wound Therapy (NPWT) is a therapeutic technique of applying sub-atmospheric pressure to a wound to reduce inflammation, manage exudate, and promote the formation of granulation tissue. It aims to optimise the natural physiological processes of wound healing for more effective recovery, and NPWT has emerged as a promising alternative to traditional dressings.

Methods: The protocol followed in the study was prospectively registered. Appropriate search terms and Boolean operators were used to search electronic databases for relevant articles. Screening of articles was performed, and data extraction was done. The effect measure was chosen according to the nature of the variable, and the effect model was chosen as per heterogeneity. Forest plot was used to give visual feedback.

Results: This study included 11 randomized controlled trials (13 publications) with a total of 1310 patients (1497 inguinal wounds). The NPWT group had lesser odds of developing surgical site infection (OR: 0.40; 95 % CI: 0.29–0.54; $n = 1491$; $I^2 = 20$ %; p-value ≤ 0.00001) and lesser odds of needing surgical wound revision (OR: 0.48; 95 % CI: 0.26–0.91; $n = 856$; $I^2 = 0$ %; p-value = 0.02) as compared to the normal dressing group. No significant difference was observed in duration of hospital stay, cost of care, wound healing time, or other complications.

Conclusion: NPWT application in inguinal wounds significantly reduces the surgical site infection and the need for wound revision in patients who have undergone vascular surgery.

Introduction

Negative Pressure Wound Therapy (NPWT) is a therapeutic technique that involves applying sub-atmospheric pressure to a wound to reduce inflammation, manage exudate, and promote the formation of granulation tissue [1]. NPWT aims to optimise the natural physiological processes of wound healing for more effective recovery. NPWT mitigates local oedema, promotes angiogenesis, enhances vascular and lymphatic

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flow, and reduces bacterial contamination [2]. In recent years, NPWT has emerged as a promising alternative to traditional dressings, offering advanced therapeutic mechanisms to enhance wound healing.

The incidence of inguinal wound complications following vascular surgeries ranges from 3 % to 44 % [3]. Patients often find traditional wound treatments, involving frequent dressing changes and repeated debridement, challenging. As a result, daily dressing changes, sometimes even multiple times a day, become necessary, often under general anaesthesia or conscious sedation. Utilising topical negative pressure in these instances brings about positive outcomes by expediting definitive wound coverage, promoting healing, and minimising the need for frequent dressings [4].

Negative Pressure Wound Therapy represents a significant and promising advancement in wound care, offering diverse clinical applications. Currently, it remains uncertain whether dressings using NPWT effectively decrease complications in the inguinal region after vascular surgery. This This study has compared outcomes like surgical site infection, time taken for wound healing, length of hospital stay, cost of care, and other complications between NPWT and conventional dressing, and the hypothesis of this study was that there was no difference between the two groups among these mentioned outcomes.

Methods

This study has followed PRISMA reporting guidelines [5].

Protocol registration

The protocol followed in this study was prospectively registered in the International prospective register of systematic reviews (PROSPERO) [6].

Search strategy

For the identification of relevant studies, electronic databases (PubMed, PubMed Central, Scopus, and Embase) were searched using the appropriate search terms combined with Boolean operators. No time filters were used at the time of the electronic database search. Details of search strategy and the results obtained from each database search are available as Supplementary File 1.

Inclusion criteria and exclusion criteria

Randomized controlled trials that compared the outcomes of negative pressure wound therapy with that of normal dressing for inguinal wounds after vascular surgery were included in this study. Comparative studies that were non-randomized, observational studies, editorials, viewpoints, and case reports were excluded.

Study selection

Covidence software [7] was used for the screening of the studies. Screening was done by two independent reviewers and a third reviewer took the role of resolving any conflicts that arose during the screening. The same procedure was followed for both title/abstract screening and full-text screening phase.

Data curation

A template was prepared in Word with headings like study details, population, intervention, comparator, and outcome for data extraction. Study details included all the identifying characteristics of the study, population included baseline parameters of the population, intervention included the name of the intervention, comparator included the name of the comparator, and under outcome, data of surgical site infection, wound healing, duration of hospital stay, cost of procedure, and complications were extracted.

Data synthesis

The odds ratio was used as the effect measure for the dichotomous variables and the standardized mean difference or mean difference was used as effect measure for continuous variables. The I-squared test assessed the heterogeneity, and fixed or random-effect model was used accordingly [8]. Fixed effect model was used for the heterogeneity 30 % and below. While, random effect model was used in case of heterogeneity above 30 %. Mean and standard deviation were derived for studies reporting median and interquartile range by using the standard conversion formula [9]. The results were expressed with a 95 % confidence interval and Forest plots were included for visual feedback.

Risk of bias assessment

The risk of bias was assessed by using the ROB tool. For this purpose, two independent reviewers assessed the studies and any disparity that arose was solved by a third reviewer. The assessment of bias is shown in Fig. 1.

Sensitivity analysis and publication bias

Sensitivity analysis was carried out for the obtained results by excluding each study at a time for every outcome. Funnel plot was used to assess the publication bias for the outcomes that included at least ten studies [8].

Results

This study included 11 randomized controlled trials (outcomes of which were published in 13 different articles) with a total of 1310 patients (1497 inguinal wounds). Search of the databases yielded a total of 1405 studies, out of which 343 studies were found to be duplicates and 1062 studies were forwarded to the screening phase. After the screening, 13 studies were identified as match and was included in the qualitative and quantitative synthesis. Details of screening is shown in Fig. 2.

Qualitative synthesis

The summary of the details of the included studies are given in Table 1.

Quantitative synthesis

Surgical site infection

Ten studies reported the data of surgical site infection and pooling of the total events reported by those studies by using fixed effect model showed that the negative pressure wound therapy (NPWT) group had 0.40 times lesser odds of developing surgical site infection (SSI), compared to normal dressing group (OR: 0.40; 95 % CI: 0.29–0.54; $n = 1491$; $I^2 = 20$ %; p-value ≤ 0.00001) (Fig. 3). Sensitivity analysis showed no significant difference in the result. Funnel plot was used to assess publication bias and it showed a symmetrical plot, denoting no publication bias (Fig. 4).

Pooling of data that reported SSI at 30 days by using fixed effect model showed that the NPWT group had 0.49 times lesser odds of developing SSI, compared to normal dressing group (OR: 0.49; 95 % CI: 0.34–0.71; $n = 893$; $I^2 = 0$ %; p-value = 0.0002) (Fig. A, Supplementary File 2). Sensitivity analysis showed no significant difference in the result.

Data on superficial infection was pooled using the fixed effect model and it showed that the NPWT group was at 0.32 lesser odds compared to the normal dressing group (OR: 0.32; 95 % CI: 0.14–0.76; $n = 494$; $I^2 = 0$ %; p-value = 0.01) (Fig. B, Supplementary File 2). On pooling the data

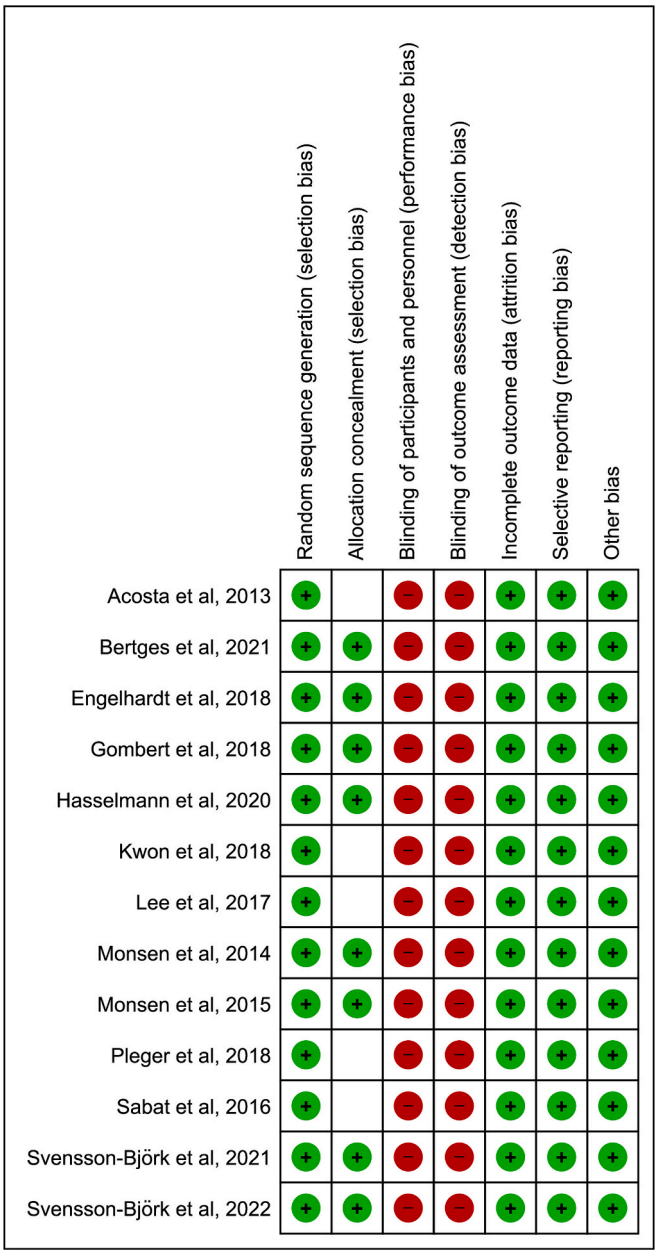

Fig. 1. ROB of included studies.

on deep infection, it showed that the NPWT group was at 0.67 lesser odds but this was not statistically significant (Fig. C, Supplementary File 2).

Wound healing time

Two trials reported the outcome of skin-epithelialization time and pooling of these data using random effect model showed that the NPWT group took 28.96 days lesser in average for wound healing as compared to the normal dressing group but the result was not found to be statistically significant (MD: −28.96; 95 % CI: (−62.76)–(4.84); $n = 30$; $I^2 = 71$ %; p-value = 0.09) (Fig. 5).

Surgical wound revision

The need for wound revision outcome was reported by five trials and on pooling of the data using the fixed effect model showed a result that favoured the NPWT group with 0.48 lesser odds of needing surgical wound revision as compared to normal dressing group (OR: 0.48; 95 % CI: 0.26–0.91; $n = 856$; $I^2 = 0$ %; p-value = 0.02) (Fig. 6). Sensitivity analysis showed no significant difference in the result.

Duration of hospital stay

Seven randomized trials reported the length of hospital stay (in days) outcome and pooling of the data using the random effect model showed that NPWT group and normal dressing group had no significant difference in duration of hospital stay. However, on removing one study [17] from the analysis, the result showed a statistically significant result that favoured the normal dressing group (MD: 0.68; 95 % CI: 0.41–0.96; $n = 711$; $I^2 = 0$ %; p-value ≤ 0.00001) (Fig. 7).

Cost of care

Pooling of the data from three studies that reported the total cost of care outcome using the random effect model yielded the result that favoured the NPWT group but the result was not found to be statistically significant (SMD: −0.13; 95 % CI: (−0.50)–(0.24); $n = 258$; $I^2 = 47$ %; p-value = 0.50) (Fig. D, Supplementary File 2).

Two studies reported the cost of wound care and pooling of the data using the random effect model yielded a result that favoured the normal dressing group but the result was not found to be statistically significant (SMD: 1.80; 95 % CI: (−0.71)–(4.32); $n = 139$; $I^2 = 92$ %; p-value = 0.16) (Fig. E, Supplementary File 2).

Complications

Pooling data on hematoma, seroma, and wound dehiscence showed that there were no significant differences between two groups in occurrence of these events. The details are given in Table 2. However, on removing one study ([22] (Bilateral)) for hematoma outcome, a statistically significant data that favoured the NPWT group was obtained (OR: 0.32; 95 % CI: 0.12–0.90; $n = 380$; $I^2 = 9$ %; p-value = 0.03) (Fig. F, Supplementary File 2).

Discussion

The inguinal wound complications after vascular surgery challenge the health-care providers and prolong the recovery time of the patients. Negative pressure wound therapy has emerged as a solution that can be used as an alternative to conventional wound dressing. This systematic review and meta-analysis of randomized controlled trials studied the outcomes of negative pressure wound therapy compared to normal dressing to determine if the NPWT has benefits over normal dressing or not.

Surgical site infection (SSI) is one of the most commonly encountered complications in the post-operative period, and the rate remains high, especially in patients with groin incisions after vascular surgery [23]. The current study found that the NPWT group had 0.40 times lesser odds of developing SSI compared to the normal dressing group when the overall SSI outcome was analysed. Also, surgical site infection at 30 days also showed that the NPWT group had 0.49 times lesser odds of developing SSI. This showed that application of negative pressure wound therapy decreases the incidence of SSI, and this finding was consistent with the findings of the majority of the randomized clinical trials that compared NPWT with normal dressing for groin wounds included in this study and other studies done among patients undergoing breast surgery [24], abdominal surgery [25,26], spine surgery [27], and caesarean section [28]. The skin epithelialization time was also studied in the current study, and it showed that the NPWT group took 28.96 days less on average for wound healing as compared to the normal dressing group, but the result was not found to be statistically significant. However, a similar study done among patients with abdominal wounds showed that wounds closed significantly faster in the NPWT arm [29]. The use of NPWT also decreased the need for wound revision and showed that the NPWT group had 0.48 lesser odds of needing surgical wound revision. Application of NPWT reduces local oedema, promotes angiogenesis, enhances vascular flow, and reduces bacterial contamination [2], making it a promising alternative to normal dressing in

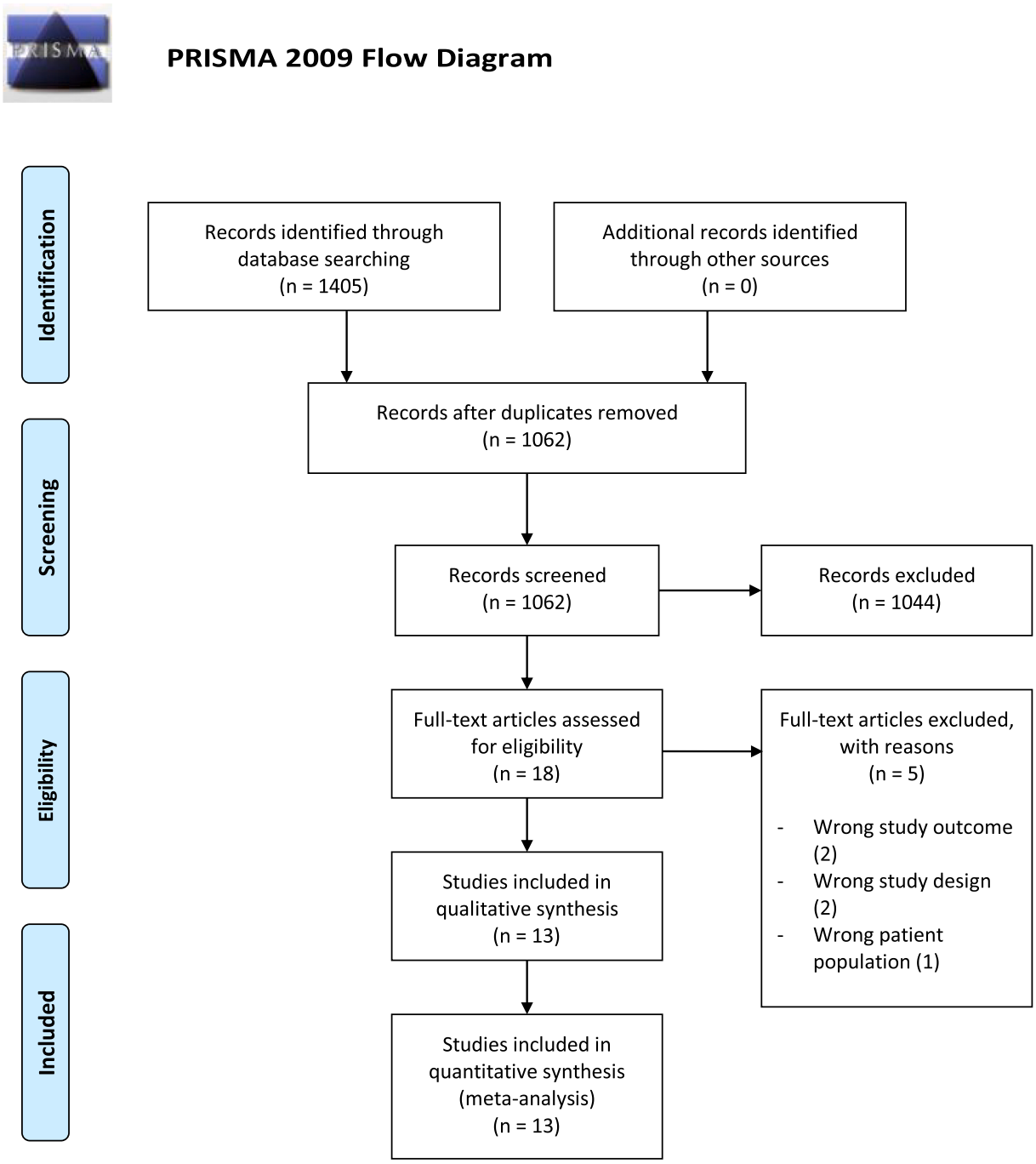

Fig. 2. PRISMA flow diagram.

reducing the odds of developing SSI.

Complications other than SSI were also studied in this study, and it was found that the occurrence of hematoma, seroma, and wound dehiscence had no significant differences between the two groups. Also, the length of hospital stay outcome did not show a statistically significant result. In cost analysis, although statistically insignificant, the total cost of care was found to be lower in the NPWT group, and the cost of wound care was found to be lower in the normal dressing group. These findings are consistent with the findings of a systematic review and meta-analysis that also included observational studies [30]. However, studies that compared the benefits of NPWT with normal dressing for incision sites other than groin showed that NPWT reduced overall surgical complications [31,32]. Another systematic review and meta-analysis that included six trials has pointed out that the benefits of NPWT in terms of duration of hospital stay, reduction of SSI, and cost of care could not be confirmed [33]. In this present study, these outcomes were studied, but the benefits of NPWT regarding the reduced cost and hospital stay could not be established. However, a reduction in surgical site infection and a lesser need for secondary wound revision have been established. The heterogeneity level for the overall SSI outcome was low, and the funnel plot also showed that there was no publication bias.

Findings of this study has established that the application of NPWT in groin incisions after vascular surgery decreases the incidence of SSI among patients, and the need for secondary wound revision is also low. But it was found that there is no difference between the two groups in aspects of duration of hospital stay, wound healing time, and other complications (hematoma, seroma, and wound dehiscence). The basis of these results can be used to make shared decisions during patient care.

Table 1
PICO details of the included studies.

RCT No.	Study ID	Population	Intervention	Comparison	Outcome
1.	Acosta et al., 2013 [10]	$N = 10$ ($T = 5$, C = 5) Male $T = 4/5$, C = 2/5 Female $T = 1/5$, C = 2/3 Age (median [IQR]) $T = 74$ (60–81), C = 74 (71–84) **Co-morbidities** Hypertension: $T = 5/5$, C = 5/5 Ischemic heart disease: $T = 3/5$, C = 3/5 Atrial fibrillation: T = 3/5, 0/5 Diabetes mellitus: $T = 2/5$, C = 3/5 Smoking: $T = 4/4$, C = 4/5 Cerebrovascular disease: $T = 1/5$, C = 0 Previous vascular surgery: T = 1/5, C = 4/5 Renal insufficiency: T = 2/5, C = 1/5 Anemia: T = 3/5, C = 5/5 Positive wound culture at surgical revision: T = 4/5, C = 3/5 **Value (median [IQR])** CRP (mg/l): $T = 189$ (4–473), C = 128 (9–297) WBC (× 109/l): $T = 8{\cdot}8$ (6·9–11·1), C = 11·0 (7·0–12·4)	Negative pressure wound therapy (NPWT)	Normal dressing	SSI (At 21–27 days): T = 2/5, C = 2/5 Proportion of healed wounds: T = 5/5, C = 4/5 Proportion of wounds treated outside hospital: T = 4/5, C = 4/5 Concomitant non-surgical foot wound: T = 2/5, C = 3/5 **Value (median [IQR])** Laser Doppler perfusion imaging: T = 1·25 (0·64–1·49), C = 0·80 (0·11–1·43) **Value (mean ± SD)** Time to full skin epithelialization (days): $T = 72 \pm 20.23$, C = 84 ± 20.22 **Complications** Failure to wound treatment: $T = 1/5$, C = 3/5 Erysipelas: T = 1/5, C = 0/5 Amputations performed: T = 2/5, C = 1/5
2.	Bertges et al., 2021 [11]	$N = 242$ ($T = 118$, C = 124) Male $T = 84/118$, C = 87/124 Female $T = 34/118$, C = 37/124 **Value (mean ± SD)** Age: $T = 67 \pm 9$, C = 67 ± 8 BMI (kg/m^2): T 28 ± 5, C = 28 ± 5 Creatinine (mg/dL): $T = 1.03 \pm 0.6$, C = 1.28 ± 1.8 Hemoglobin A1c (%): $T = 6.9 \pm 1.5$, C = 6.9 ± 1.6 **Smoking** Never: T = 7/118, C = 9/124 Former: $T = 71/118$, C = 82/124 Active: $T = 40/118$, C = 33/124 **Diabetes mellitus** IDDM: $T = 17/118$, C = 29/124 NIDDM: $T = 31/118$, C = 30/124 CAD: $T = 59/118$, C = 58/124 CHF: T = 17/118, C = 16/124 Renal insufficiency (CR >2 mg/dL): T = 5/118, C = 9/124 Dialysis: T = 3/118, C = 5/124 Hypertension: $T = 100/118$, C = 107/124 Preoperative antibiotics: $T = 0/118$, C = 1/124 Post-operative antibiotics: $T = 61/118$, C = 62/124	Negative pressure wound therapy (NPWT)	Normal dressing	**At 30 days** Readmission for wound infection: $T = 8/118$, C = 11/124 **Value (mean ± SD)** Length of hospital stay (days): $T = 5.7 \pm 8.06$, C = 5.2 ± 8.06 **Complications** SSI: $T = 14/118$, C = 15/124 Wound dehiscence: $T = 17/118$, C = 17/124 Ischemia: $T = 2/118$, C = 1/124 Lymph leak: $T = 2/118$, C = 2/124 Seroma/hematoma: T = 3/118, C = 1/124 Amputation: T = 0/118, C = 1/124 Graft revision: $T = 1/118$, C = 3/124 Mortality: T = 1/118, C = 1/124
3.	Engelhardt et al., 2018 [12]	$N = 132$ ($T = 64$, C = 68) Male $T = 48/64$, C = 57/68 Female $T = 16/64$, C = 11/68 **Value (median [IQR])** Age: $T = 72$ (64–75), C = 70 (60–78) BMI: $T = 27$ (25–29), C = 27 (24–30) **Co-morbidities** Diabetes: $T = 19/64$, C = 20/68 Smoker: T = 48/64, C = 54/68 **Diagnosis**	Negative pressure wound therapy (NPWT)	Normal dressing	**At 5 days** SSI: $T = 4/64$, C = 10/68 **At 42 days** SSI: $T = 9/64$, C = 19/68

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Table 1 (*continued*)

RCT No.	Study ID	Population	Intervention	Comparison	Outcome
		PAD II: $T = 43/64$, C = 49/68 PAD III: T = 7/64, C = 3/68 PAD IV: $T = 11/64$, C = 12/68 Aneurysm: T = 3/64, C = 4/68			
4.	Gombert et al., 2018 [13]	$N = 188$ ($T = 98$, C = 90) Male $T = 70/98$, C = 62/90 Female $T = 28/98$, C = 28/90 **Value (mean ± SD)** BMI: $T = 26.9 \pm 4.8$, C = 25.7 ± 4.6 Baseline urea (mg/dl): $T = 46.5 \pm 17.9$, C = 52.4 ± 23.7 **Value (median [IQR])** Baseline creatinine (mg/dl): $T = 1.4$ (1.2–1.7), C = 1.4 (1.2–1.6) Length of hospital stay (days): $T = 8$ (7–11), C = 8 (6–9) **Co-morbidities** Arterial hypertension: T = 98/98, C = 86/90 Coronary heart disease: $T = 56/98$, C = 44/90 History of Myocardial infarction: $T = 22/98$, C = 24/90 History of stroke: T = 18/98, C = 14/90 Diabetes: $T = 42/98$, C = 22/90 Dyslipidemia: $T = 94/98$, C = 82/90 Chronic kidney disease: $T = 32/98$, C = 26/90 COPD: $T = 24/98$, C = 17/90 **Diagnosis** PAD II: $T = 50/98$, C = 49/90 PAD III: $T = 29/98$, C = 24/90 PAD IV: T = 19/98, C = 17/90	Negative pressure wound therapy (NPWT)	Normal dressing	**At 30 days** SSI: $T = 13/98$, C = 30/90 Alternative wound dressing: T = 13/98, C = 21/90 Antibiotic treatment: T = 13/98, C = 28/90 Surgical revision: T = 5/98, C = 6/90 **Value (mean ± SD)** C-reactive protein (mg/L): $T = 57.75 \pm 21.07$, C = 40.75 ± 13.57 Leucocytes (per mL): $T = 10.5 \pm 4.1$, C = 9.0 ± 2.6 Length of hospital stay (days): $T = 8.5 \pm 1.15$, C = 7.75 ± 0.82
5.	Hasselmann et al., 2020 [14]	**Unilateral Group** N1 = 120 (T1 = 59, C1 = 61) Male T1 = 44/59, C1 = 44/61 Female T1 = 15/59, C1 = 17/61 BMI kg/m^2 (Median): T1 = 26.0, C1 = 26.4 GFR in mL/min/1.73 m^2 (Median): T1 = 67.5, C1 = 74 Current smokers: T1 = 16/59, C1 = 19/61 Pre-operative antibiotic treatment: T1 = 2/59, C1 = 3/61 Intraoperative antibiotic prophylaxis: T1 = 57/59, C1 = 57/61 Local antibiotic material: T1 = 6/59, C1 = 2/61 Antimicrobial incision drapes: T1 = 12/59, C1 = 14/61 Procedural time in minutes (Median): T1 = 193, C1 = 187 **Co-morbidities** Cardiovascular disease: T1 = 11/59, C1 = 12/61 Arterial hypertension: T1 = 46/59, C1 = 51/61 Ischemic heart disease: T1 = 26/59, C1 = 25/61 Diabetes mellitus: T1 = 19/59, C1 = 22/61 Anemia: T1 = 23/59, C1 = 27/61 **Bilateral group** N2 = 19 Male = 13	Negative pressure wound therapy (NPWT) (T1 = Unilateral groin wound group; T2 = Bilateral groin wound group)	Normal dressing (C1 = Unilateral group; C2 = Bilateral group)	**At 90-days** **Unilateral Group** SSI: T1 = 7/59, C1 = 18/61 Disturbed wound healing: T1 = 6/59, C1 = 2/61 Minor wound infection: T1 = 6/59, C1 = 12/61 Moderate wound infection: T1 = 1/59, C1 = 4/61 Severe wound infection: T1 = 0, C1 = 2/61 Superficial infection: T1 = 6/59, C1 = 13/61 Deep infection: T1 = 1/59, C1 = 2/61 Organ/space infection: T1 = 0, C1 = 2/61 Surgical wound revision: T1 = 2/59, C1 = 4/61 Hematoma: T1 = 1/59, C1 = 4/61 Seroma/lymphocele: T1 = 13/59, C1 = 14/61 Wound dehiscence: T1 = 12/59, C1 = 7/61 **Value (mean ± SD)** Length of hospital stay (days): T1 = 7 ± 3.84, C1 = 7 ± 2.30 **Bilateral group** SSI: T2 = 1/19, C2 = 5/19 Disturbed wound healing: T2 = 1/19, C2 = 1/19 Minor wound infection: T2 = 1/19, C2

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Table 1 (*continued*)

RCT No.	Study ID	Population	Intervention	Comparison	Outcome
		Female = 6 BMI kg/m^2 (Median) = 25.2 GFR in mL/min/1.73 m^2 (Median) = 70 Current smokers = 6/19 Pre-operative antibiotic treatment = 2/19 Intraoperative antibiotic prophylaxis = 17/19 Local antibiotic material = 2/19 Antimicrobial incision drapes = 6/19 Procedural time in minutes (Median) = 254 Hospital stay (median) = 9 (6) **Co-morbidities** Cardiovascular disease = 3/19 Arterial hypertension = 16/19 Ischemic heart disease = 6/19 Diabetes mellitus = 3/19 Anemia = 8/19			= 4/19 Superficial infection: T2 = 1/19, C2 = 5/19 Surgical wound revision: T2 = 1/19, C2 = 1/19 Seroma/lymphocele: T2 = 3/19, C2 = 4/19 Wound dehiscence: T2 = 2/19, C2 = 2/19
	Svensson-Björk et al., 2021 [15]				**Unilateral group** **Cost of care** Hospital care (USD): *T* = 20,529.44 ± 13,364.71, C = 18,712.98 ± 13,364.71 Wound material (USD): *T* = 221.99 ± 283.47, C = 48.03 ± 283.47
6.	Kwon et al., 2018 [16]	*N* = 119 (*T* = 59, C = 60) Male *T* = 26/59, C = 36/60 Female *T* = 33/59, C = 24/60 **Value (median [IQR])** BMI >30 kg/m^2: *T* = 19/59, C = 13/60 Pannus: T = 26/59, C = 28/60 Prosthetic graft: *T* = 38/59, C = 39/60 Por nutrition: T = 1/59, C = 1/60 Immunosuppression: T = 1/59, C = 1/60 HbA1c >8 %: *T* = 4/59, C = 4/60	Negative pressure wound therapy (NPWT)	Normal dressing	**At 30-days** SSI: *T* = 6/59, C = 12/60 Wound dehiscence: T = 1/59, C = 1/60 Hematoma: *T* = 0, C = 1/60 Lymph leak: T = 0, C = 2/60 Revision operation: T = 5/59, C = 11/60 Readmission: T = 4/59, C = 10/60 Hospital cost (USD): *T* = 30,492 ± 30,678, C = 36,537 ± 28,889
7.	Lee et al., 2017 [17]	*N* = 102 (*T* = 53, C = 49) Male *T* = 34/53, C = 45/49 Female T = 19/53, C = 4/49 **Value (mean ± SD)** BMI, kg/m^2: T = 29 ± 5, C = 29 ± 10 Procedural time in hours: *T* = 2.5 ± 1.0, C = 2.5 ± 0.75 Coronary artery disease: *T* = 23/53, C = 22/49 Left ventricular dysfunction: T = 2/53, C = 3/49 Hypertension: *T* = 45/53, C = 42/49 Diabetes mellitus: *T* = 25/53, C = 26/49 Chronic obstructive pulmonary disease: *T* = 11/53, C = 2/49 Chronic kidney disease: T = 6/53, C = 6/49 Anticoagulation: T = 8/53, C = 10/49 ASA III: T = 25/53, C = 21/49 ASA IV: T = 25/53, C = 22/49 BMI >30 kg/m^2: T = 22/53, C = 17/49 Previous revascularization: T = 17/53, C = 13/49	Negative pressure wound therapy (NPWT)	Normal dressing	SSI (At 30-day): T = 6/53, C = 9/49 SSI (At 90-day): *T* = 7/53, C = 11/49 Readmission rate: T = 2/53, C = 2/49 Revision operation: T = 2/53, C = 1/49 Mortality within 90-days: T = 1/53, C = 2/49 Length of hospital stay: T = 6 ± 3, C = 9 ± 6
8.	Monsen et al., 2014 [18]	*N* = 20 (T = 10, C = 10) Male T = 8/10, C = 5/10 Female T = 2/10, C = 5/10 **Value (median [IQR])** Age: *T* = 71 (60–81), C = 73 (66–84) BMI: T = 26 (22.3–37.3), C = 31.5 (23.9–39.8) C-reactive protein (mg/L): *T* = 150 (4–473), C = 128 (9–370) Leukocytes (10^9/L): *T* = 9.3	Negative pressure wound therapy (NPWT)	Normal dressing	Time for full-skin epithelialization (days): *T* = 63.5 ± 25.99, C = 110 ± 34.07 Length of hospital stay: *T* = 31 ± 25.43, C = 30.5 ± 20.22 **Wound surface area (cm^2):** At day 0: *T* = 18.8 (7.6–37.6), C = 22.3 (4.6–44.5) At 7: *T* = 12.0 (1.3–44.9), C = 16.6 (5.9–53.8) At 14: *T* = 7.5 (0.6–92.5), C = 10.8

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Table 1 (*continued*)

RCT No.	Study ID	Population	Intervention	Comparison	Outcome
		(6.2–13.5), C = 11.0 (7.0–14.8) **Co-morbidities** Ischemic heart disease: T = 5/10, C = 8/10 Diabetes mellitus: T = 4/10, C = 7/10 Cerebrovascular disease: T = 2/10, C = 2/10 Previous vascular surgery: T = 5/10, C = 8/10			(2.0–33.8) At 21: *T* = 3.5 (0–92.5), C = 6.5 (2.7–26.3) **C-reactive protein:** At day 7: T = 11 ± 48.00, C = 20 ± 48.00 At day 14: T = 7 ± 17.75, C = 13 ± 17.75 At day 21: T = 6 ± 27.59, C = 9 ± 27.59
	Monsen et al., 2015 [19]				**Cost of care** Hospital care (USD): T = 12,063.13 ± 3544.87, C = 15,495.40 ± 5320.69 Wound material (USD): *T* = 877.01 ± 244.31, C = 283.89 ± 63.47
9.	Pleger et al., 2018 [20]	*N* = 100 (*T* = 43, C = 57) Male T = 29/43, C = 43/57 Female *T* = 14/43, C = 14/57 **Value (median [IQR])** Age: T = 71 (54–89), C = 66.5 (41–86) BMI: T = 26·7 (19·1–37·3), C = 27·8 (18·4–37·2) Mean wound length (cm): T = 7·7 (5–15), C = 8·6 (5–15) **Co-morbidities** Hypertension: T = 38/43, C = 53/57 Coronary artery disease: T = 22/43, C = 13/57 Diabetes mellitus: T = 22/43, C = 29/57 Renal insufficiency: *T* = 27/43, C = 30/57 COPD: T = 9/43, C = 8/57 Smoker: T = 23/43, C = 22/57 Infrarenal abdominal aortic aneurysm: T = 14/43, C = 7/57 Thoracic abdominal aortic aneurysm: T = 3/43, C = 5/57	Negative pressure wound therapy (NPWT)	Normal dressing	**Wound infection:** At day 7: T = 0/43, C = 5/57 At day 30: T = 5/43, C = 15/57 Total SSI: T = 5/43, C = 30/57 Wound revision: T = 1/43, C = 10/57 Length of hospital stay: *T* = 18.4 ± 10.98, C = 18.75 ± 11.27 **Complications:** Wound dehiscence: T = 4/43, C = 8/57 Skin necrosis: T = 1/43, C = 3/57 Hematoma: T = 0/43, C = 8/57 Seroma: T = 0/43, C = 1/57
10.	Sabat et al., 2016 [21]	N = 49 Total groin incision = 63 (T = 30, C = 33)	Negative pressure wound therapy (NPWT)	Normal dressing	**At 4 months** SSI: T = 2/30, C = 7/33 Wound dehiscence: T = 1/30, C = 1/33
11.	Svensson-Björk et al., 2022 [22]	**Unilateral Group** N1 = 41 (T1 = 15, C1 = 26) Male T1 = 10/15, C1 = 18/26 Female T1 = 5/15, C1 = 8/26 BMI kg/m^2 (Median): T1 = 28.7, C1 = 26.0 Current smoker: T1 = 2/15, C1 = 4/26 Past smoker: T1 = 9/15, C1 = 17/26 Anticoagulants: T1 = 4/15, C1 = 5/26 Steroid therapy: T1 = 0/15, C1 = 2/26 **Co-morbidities:** Hypertension: T1 = 15/15, C1 = 21/26 Ischemic heart disease: T1 = 7/15, C1 = 12/26 Peripheral artery disease: T1 = 0/15, C1 = 6/26 Cerebrovascular disease: T1 = 4/15, C1 = 0/26 Atrial fibrillation: T1 = 3/15, C1 = 4/26 Diabetes mellitus: T1 = 5/15, C1 =	Negative pressure wound therapy (NPWT) (T1 = Unilateral groin wound group; T2 = Bilateral groin wound group)	Normal dressing (C1 = Unilateral group; C2 = Bilateral group)	**At 90-days** **Unilateral Group** SSI: T1 = 2/15, C1 = 3/26 Disturbed wound healing: T1 = 0/15, C1 = 0/26 Minor wound infection: T1 = 0/15, C1 = 0/26 Moderate wound infection: T1 = 0/15, C1 = 0/26 Severe wound infection: T1 = 2/15, C1 = 3/26 Deep infection: T1 = 2/15, C1 = 3/26 Hematoma: T1 = 3/15, C1 = 5/26 Seroma/lymphocele: T1 = 0/15, C1 = 1/26 Wound dehiscence: T1 = 2/15, C1 = 3/26 Surgical revision: T1 = 2/15, C1 = 3/26 Length of hospital stay: T = 7 ± 4.61, C = 8 ± 5 **Bilateral group**

(*continued on next page*)

Table 1 (*continued*)

RCT No.	Study ID	Population	Intervention	Comparison	Outcome
		2/26 Previous vascular surgery: T1 = 6/15, C1 = 9/26			SSI: T2 = 3/168, C2 = 8/168 Disturbed wound healing: T2 = 5/168, C2 = 5/168 Minor wound infection: T2 = 1/168, C2 = 3/168 Moderate wound infection: T2 = 0/168, C2 = 1/168 Severe wound infection: T2 = 2/168, C2 = 4/168
		Bilateral group N2 = 168 Male = 146 Female = 22 BMI kg/m^2 (Median): 27.0 Current smoker: 42/168 Past smoker: 105/168 Anticoagulants: 32/168 Steroid therapy: 22/168 **Co-morbidities:** Hypertension: 130/168 Ischemic heart disease: 69/168 Peripheral artery disease: 9/168 Cerebrovascular disease: 26/168 Atrial fibrillation: 33/168 Diabetes mellitus: 34/168 Previous vascular surgery: 22/168			Superficial infection: T2 = 1/168, C2 = 4/168 Deep infection: T2 = 2/168, C2 = 4/168 Hematoma: T2 = 16/168, C2 = 15/168 Seroma/lymphocele: T2 = 3/168, C2 = 8/168 Wound dehiscence: T2 = 4/168, C2 = 6/168 Surgical revision: T2 = 2/168, C2 = 3/168

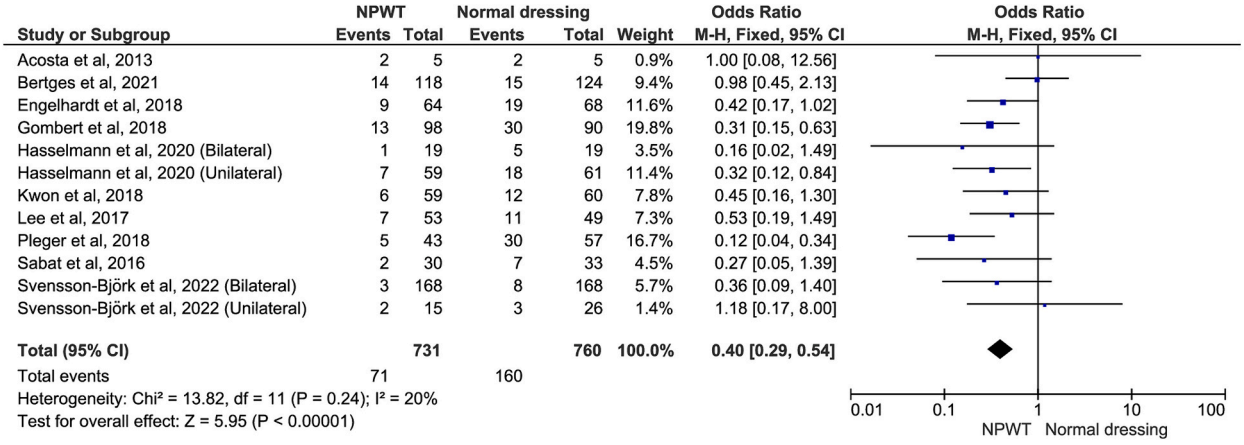

Fig. 3. Overall surgical site infection outcome.

Patients who are prone to developing SSI, and in circumstances where healthcare providers perceive the risk of SSI, NPWT can be very useful in such states. Also, the need for frequent dressing changes is also solved by the use of NPWT. Although the analysis of this study showed no difference in terms of cost of care and duration of hospital stay, if the incidence of SSI and the need for secondary wound revision could be reduced for the patients, the cost of care and duration of hospital stay would become lower, provided that there were no other ailments. This should be assessed by the healthcare providers at the local level, and shared decision-making should be opted for.

The wound healing time outcome was reported in only two of the included studies, and its analysis showed high heterogeneity. Similarly, the cost of wound care was also reported in only two of the included studies, and its analysis showed high heterogeneity. The lack of data on these outcomes is the limitation of this systematic review and meta-analysis. Further studies with a focus on the wound healing time and the cost factor are needed to assess the recovery time and cost-effectiveness.

Conclusion

Negative pressure wound therapy application in inguinal wounds significantly reduces surgical site infection and the need for wound revision in patients who have undergone vascular surgery. Patients with risk factors for developing surgical site infections and needing to change the wound dressing frequently can benefit from this. Shared decision-making is necessary as there is no difference in duration of hospital stay, cost of care, wound healing time, or other complications.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sopen.2024.03.018.

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This study did not receive any grants.

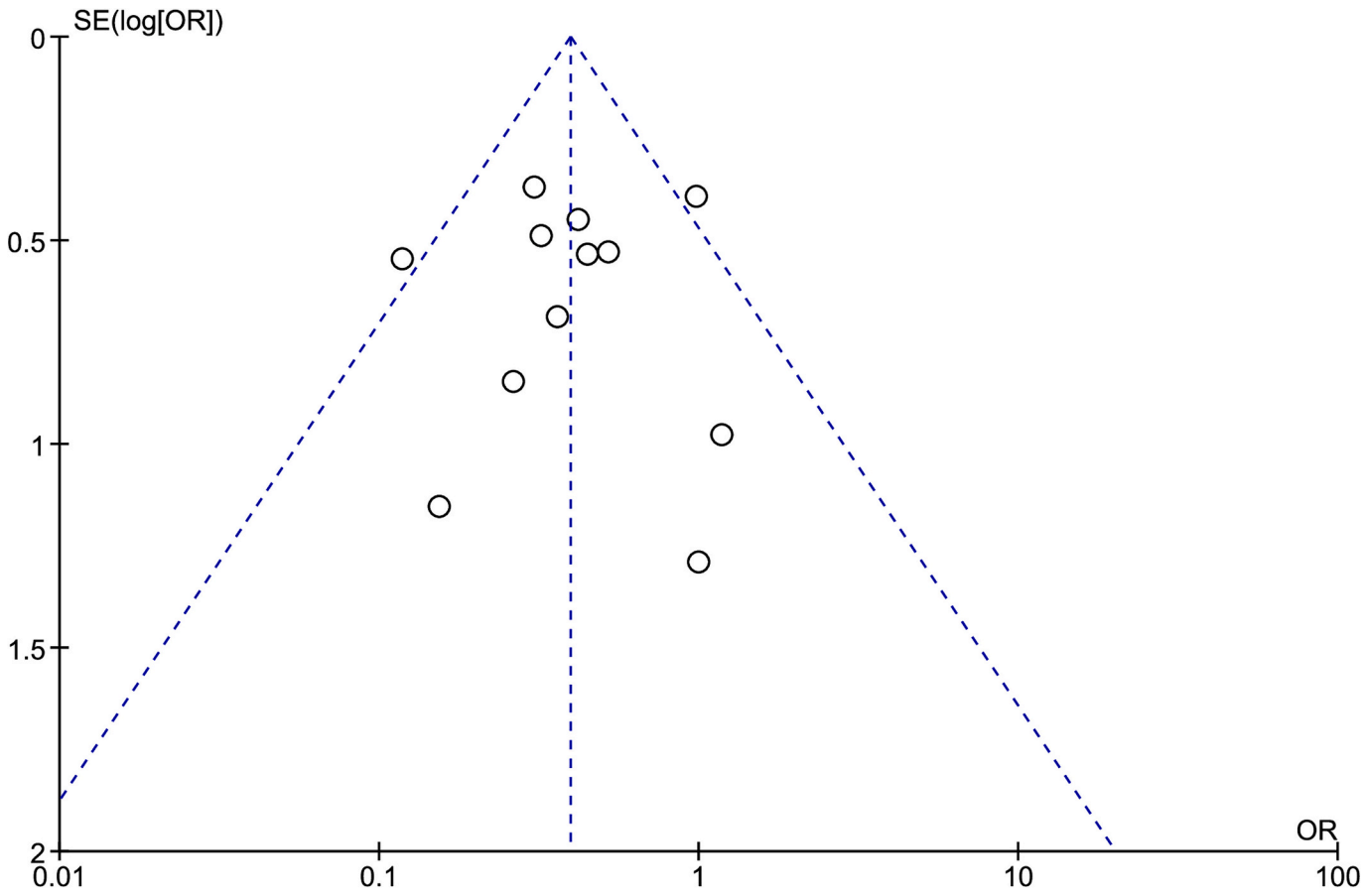

Fig. 4. Funnel plot for surgical site infection outcome.

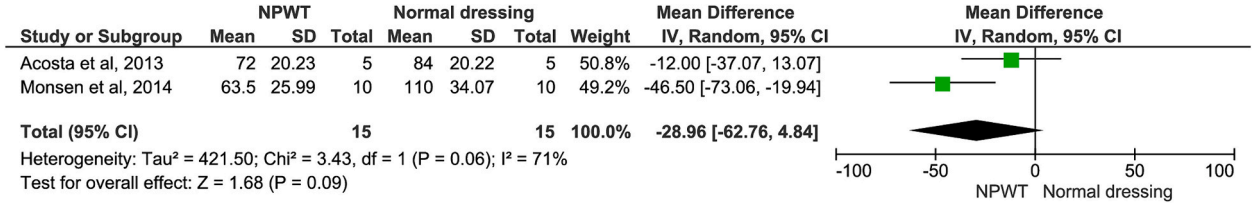

Fig. 5. Wound healing time outcome.

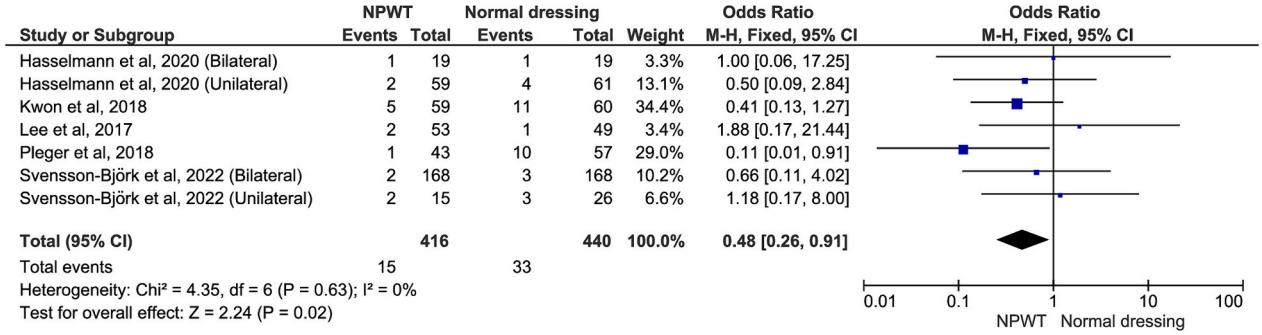

Fig. 6. Surgical wound revision outcome.

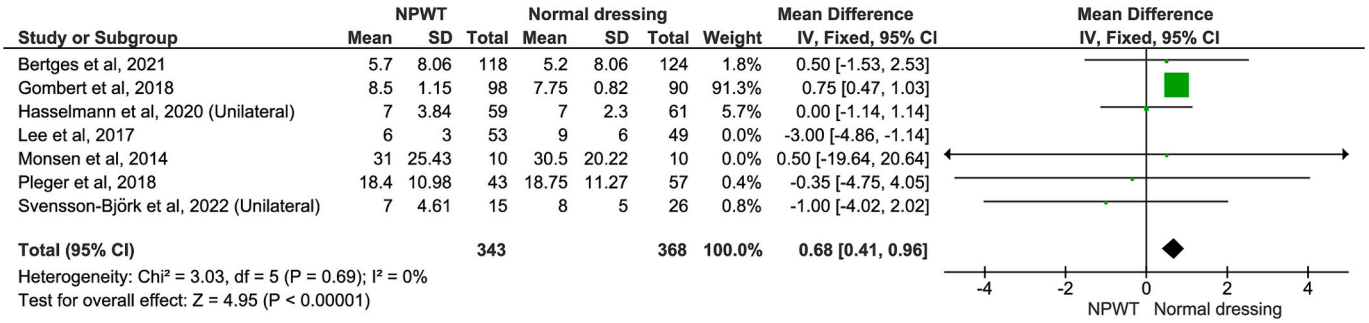

Fig. 7. Duration of hospital stay outcome.

Table 2
Post-operative complications.

Outcomes	Effect measure	Effect model	Heterogeneity	Significance
Hematoma	OR: 0.67; 95 % CI: 0.38–1.19	Fixed	24 %	0.18
Seroma	OR: 0.68; 95 % CI: 0.36–1.27	Fixed	0 %	0.23
Wound dehiscence	OR: 1.06; 95 % CI: 0.68–1.66	Fixed	0 %	0.79

Abbreviations: OR: odds ratio, CI: confidence interval.

Ethical approval

Not applicable for systematic review and meta-analysis.

Patient consent

Not applicable for systematic review and meta-analysis.

Provenance and peer review

Not commissioned, externally peer-reviewed.

CRediT authorship contribution statement

Oshan Shrestha: Writing – review & editing, Writing – original draft, Validation, Software, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Sunil Basukala:** Writing – review & editing, Validation, Supervision, Project administration, Formal analysis, Conceptualization. **Nabaraj Bhugai:** Writing – review & editing, Writing – original draft, Validation, Methodology, Data curation. **Sujan Bohara:** Methodology, Project administration, Validation, Writing – review & editing, Writing – original draft. **Niranjan Thapa:** Writing – review & editing, Validation, Data curation, Conceptualization. **Sushanta Paudel:** Writing – review & editing, Validation, Project administration, Data curation. **Suvam Lahera:** Writing – review & editing, Validation, Data curation. **Sumit Kumar Sah:** Writing – review & editing, Validation, Data curation. **Sujata Ghimire:** Writing – review & editing, Validation, Data curation. **Bishal Kunwor:** Writing – review & editing, Writing – original draft, Validation, Project administration. **Suchit Thapa Chhetri:** Writing – review & editing, Writing – original draft, Validation, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that was collected and analysed are within the manuscript.

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