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Are high-risk patient and revision arthroplasty effective indications for closed-incisional negative-pressure wound therapy after total hip or knee arthroplasty? A systematic review and meta-analysis

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Abstract

To determine the effective indications of closed-incisional negative-pressure wound therapy (ciNPWT) following total hip or knee arthroplasty, this systematic review and meta-analysis was conducted. The systematic search was performed on MEDLINE, Embase, and Cochrane Library, and 11 studies were included. The studies comparing between ciNPWT and conventional dressings were categorised into following subgroups based on patient risk and revision procedures: routine vs high-risk patient; primary vs revision arthroplasty. Pooled estimates were calculated for wound complication and surgical site infection (SSI) rates in the subgroup analyses using Review Manager. In high-risk patients, the overall rates of wound complication (odds ratio [OR] = 0.38; 95% confidence interval [CI] 0.15-0.93; $P = .030$) and SSI (OR = 0.24; 95% CI = 0.09-0.64; $P = .005$) were significantly lower in the ciNPWT; however, there were no differences in routine patients. In cases involving revision arthroplasties, the overall rates of wound complication (OR = 0.33; 95% CI = 0.18-0.62; $P < .001$) and SSI (OR = 0.26; 95% CI = 0.11-0.66; $P = .004$) were significantly lower in the ciNPWT; however, there were no differences in cases involving primary arthroplasties. In summary, ciNPWT showed a positive effect in decreasing the rates of wound complication and SSI in high-risk patients and in revision arthroplasties.

KEYWORDS

closed-incisional negative-pressure wound therapy, surgical site infection, total hip arthroplasty, total knee arthroplasty, wound complication

1 | INTRODUCTION

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are the most common and successful operations in modern medicine.[1,2] However, persistent surgical site complications (SSCs), such as wound complications and surgical site infection (SSI) after THA and TKA, are major sources for periprosthetic joint infection (PJI) and remain concerns to orthopaedic surgeons.[3-6] Despite the low incidence, deep PJI has a devastating impact on not only the heath burden but also the distress or the economic burden to patients.[3,7-9]

Given its considerable burden, great efforts to identify preoperative risk factors and to prevent SSCs and PJI in

various ways have been made to date. Previous studies have demonstrated that the risk of SSCs and PJI can be significantly different based on the individual patient and the surgical risk factors.[2,6,10,11] Tan et al[2] demonstrated that a patient's comorbidities and the revision procedures should be considered as valid risk factors for PJI and the incidence of developing PJI can vary from 0.6% to 20.6% based on the risk factors. Because patients with certain risk factors are frequently associated with SSCs, a variety of dressing materials were applied to prevent SSCs.[4,12,13] However, the proper indication and the best choice of dressing materials for wound management after THA and TKA still remains unclear.

Closed-incisional negative-pressure wound therapy (ciNPWT) has been recently developed and has shown better efficacy in decreasing SSCs than conventional dressings after THA or TKA.[3,4,10,14] Although a recent study showed the routine application of ciNPWT to all patients to be a cost-effective intervention to reduce SSCs after primary THA and TKA,[15] the cost of ciNPWT application is substantially increased over that of conventional dressings.

Therefore, we designed a systematic review and meta-analysis to determine the effective indication for ciNPWT in wound management following THA or TKA. We asked the following questions: Does the use of ciNPWT following THA or TKA compared with conventional dressings reduce the incidence of wound complication or SSI in (a) high-risk patients compared with routine patients? and (b) revision arthroplasties compared with primary arthroplasties?

Key Messages

- the application of closed-incisional negative-pressure wound therapy (ciNPWT) reduced the incidence of wound complication and surgical site infection (SSI) in high-risk patients and in revision procedures after total hip arthroplasty or total knee arthroplasty compared with conventional dressings
- our findings would support the evidence to determine effective indication for ciNPWT application in high-risk patients and in revision arthroplasties
- the wound complication and SSI were significantly less likely to occur in the high-risk patients or in revision arthroplasties using ciNPWT compared with conventional dressings
- there were no significant differences of wound complication and SSI in routine patients or in primary arthroplasties between ciNPWT and conventional dressings

2 | MATERIALS AND METHODS

2.1 | Literature search

The present systematic review followed the recommendation of the Cochrane review methods. Based on the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines,[16] multiple comprehensive literature databases, including PubMed (MEDLINE), Embase, and the Cochrane Library were searched for studies that reported on the outcomes of ciNPWT in wound management following THA or TKA up to September 1st, 2019 using a prior search strategy. There were no restrictions on language or the year of publication. The search terms used in the title, abstract, Medical Subjects Heading, and keywords fields included the following search methodology: ("ciNPT" OR "ciNPWT" OR "closed incisional negative pressure therapy" OR "closed incisional negative wound therapy" OR "negative pressure wound therapy" OR "NPWT" OR "vacuum assisted closure" OR "VAC") AND ["TKA" OR "total knee arthroplasty" OR "total knee replacement" OR "arthroplasty, replacement, knee") OR ("THA" OR "total hip arthroplasty" OR "total hip replacement" OR "arthroplasty, replacement, hip")]. Manual searches were also performed for articles that could have been missed by the electronic search.

2.2 | Study selection

Two reviewers independently evaluated titles and abstracts of the identified studies and selected eligible studies for a full review. If the abstract showed insufficient information for a decision, the full text of the article was reviewed. Articles that satisfied the following criteria were selected in this systematic review: (a) patients who underwent THA or TKA using ciNPWT for their surgical incisions; (b) studies that directly compared ciNPWT and conventional dressings in terms of wound complications and SSI; and (c) studies that fully reported the complete numbers of patients or enabled the calculation of the number and proportion of patients regarding wound complications and SSI. Studies not clearly reporting data regarding either wound complication or SSI, indicating vague definition of terms between wound complication and SSI, biomechanical and cadaveric studies, technical

notes, letters to the editor, expert opinions, review articles, meta-analyses, scientific conference abstracts, and case reports were excluded. A study of cohorts undergoing ciNPWT for periprosthetic fractures of THA and TKA was also excluded.

2.3 | Data extraction

Two investigators independently extracted data from each article using a predefined data extraction form. Any disagreements between two reviewers were solved by discussion. The extracted outcomes were SSCs including wound complications and SSI. Wound complications included wound discharge, wound dehiscence, hematoma, and seroma. The number of overall wound complications was reported in most included studies, if not, we added the number of specific wound complications. SSIs included both superficial and deep infection. Patient demographic, characteristic, and population data including sample size, mean age, sex, mean body mass index (BMI), and follow-up period were recorded for each included study. If the follow-up periods for wound complications and SSI were different, each follow-up period was separately recorded. Details of wound management such as the specific material and duration of dressing changes were extracted from each included study. Details of study indications were also extracted from pooled studies such as whether routine patients were included or high-risk patients having comorbidities were included, and whether primary and/or revision and THA and/or TKA was performed.

2.4 | Assessment of methodological quality

Two investigators independently assessed the methodological quality of each study using the methodological index for non-randomised studies (MINORS).[17] Using the MINORS checklist, the maximum score is 24 for a comparative study. Furthermore, MINORS has validity to assess the qualities of randomised controlled trials (RCTs) as well as non-randomised studies. Any discrepancies in the scores between the two reviewers were resolved by discussion.

3 | STATISTICS

Wound complication and SSI data recorded in the included studies were pooled. The main outcomes of the present study were mean differences in wound complication and SSI between ciNPWT and conventional dressings based on subgroups of patients as follows: routine patients vs high-risk patients; primary arthroplastis vs revision arthroplastis. Thus, subgroup analyses of the studies were performed to determine the effective indication of ciNPWT after THA or TKA. Random-effects meta-analyses were performed to pool the outcomes across the included studies. Binary outcomes, such as the rates of wound complication and SSI were reported as odds ratios (ORs) and 95% confidence intervals (CIs). Heterogeneity was determined by estimating the proportion of between-study inconsistencies because of actual differences between studies, rather than differences because of random error or chance, using the I^2 statistic, where 25% was considered low heterogeneity, 50% was considered moderate heterogeneity, and 75% was considered high heterogeneity. Forest plots were used to show the outcome, pooled estimate of effect, and overall summary effect of each study and constructed using the Review Manager software (RevMan version 5.3; Copenhagen, The Nordic Cochrane Centre, The Cochrane Collaboration). A meta-regression analysis was performed to assess the effects of age, sex, and follow-up period on wound complication and SSI. Analyses were performed using RevMan version 5.3 and Open Meta-Analyst (http://www.cebm.brown.edu/openmeta). Statistical significance was set at $P < .05$.

4 | RESULTS

4.1 | Identification of studies

Figure 1 shows the detail of the study identification, inclusion, and exclusion. An electronic search yielded 51 studies in PubMed (MEDLINE), 31 in Embase, and 35 in the Cochrane Library. An additional study was identified through manual searching. After removing 52 duplicate studies, 66 studies remained. After screening the titles and abstracts, and reading the full text, 55 studies were excluded. Thus, 11 studies were finally included in the present study, of which eight RCTs[3,4,18-23] and three cohort studies[10,14,24] were eligible for data extraction and meta-analysis.

4.2 | Study characteristics and methodological quality assessment

A total of 1997 cases of THA or TKA were reported including 763 cases with ciNPWT management and 1234 cases with conventional wound management. The details of the study design and patient and population

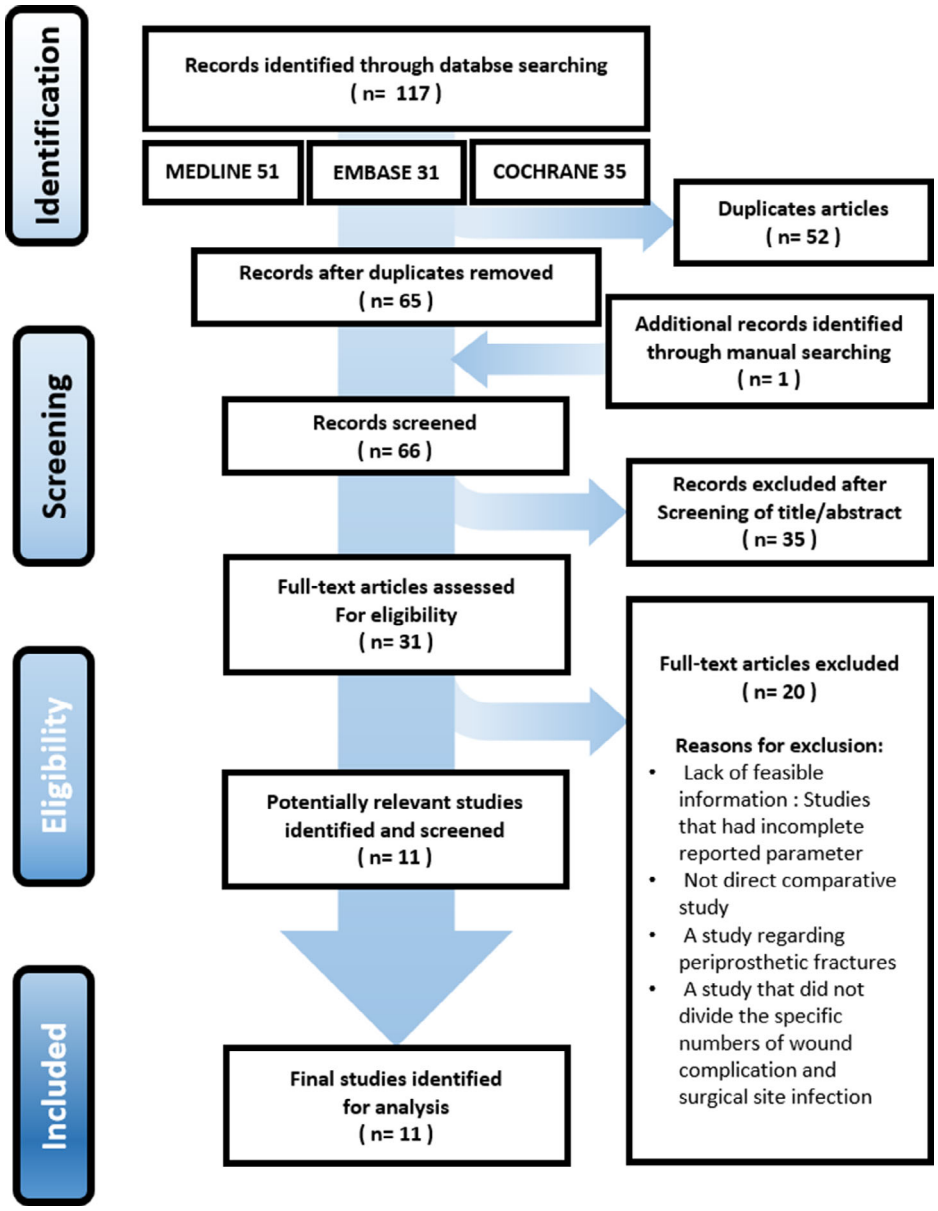

FIGURE 1 Flow diagram showing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology

characteristics including age, percentage of female, mean BMI, follow-up period, and MINORS quality score of each included study are summarised in Table 1. The median MINORS score of the included studies was 20 of 24 (range 16-24). The details of wound management in ciNPWT and conventional wound dressings, the specific study indications for patients at risk, and the type of surgery are described in Table 2. Publication bias was not investigated for as it is not generally necessary when meta-analyses include fewer than 10 studies.[25]

4.3 | Routine patients vs high-risk patients

In terms of wound complication, there were 6 studies with a total of 548 and 801 routine patients who received ciNPWT and conventional dressings, respectively. The overall rate of wound complication in routine patients was not significantly different between the ciNPWT and the conventional dressings (OR = 0.52; 95% CI = 0.21-1.33; $P = .17$). Four studies included a total of 165 and 383 high-risk patients for wound complication who received ciNPWT and conventional dressings, respectively. The overall rate of wound complication in high-risk patients was significantly lower in the ciNPWT group than in the conventional dressings, and the summary OR was 0.38 (95% CI = 0.15-0.93; $P = .03$) (Figure 2A). In terms of SSI, there were five studies with a total of 539 and 791 routine patients who received ciNPWT and conventional dressings, respectively. The overall rate of SSI in routine patients was not significantly different between the ciNPWT and the conventional dressings (OR = 0.49; 95% CI = 0.22-1.11; $P = .09$). Five studies

TABLE 1 The details of demographic data and quality scores of the included studies[a]

Author	Year	Study type	Sample size (n)		Mean age (years)		Percentage of female		BMI (kg/m^2)		Follow-up	MINORS score
			ciNPWT	Control	ciNPWT	Control	ciNPWT	Control	ciNPWT	Control		
						Main findings						
Cooper and Bas	2016	RCS	30	108	71.7	70.9	NR		31.3	29.6	Wound: 4 weeks SSI: over 34 months	19
	ciNPWT may decrease wound complications and SSIs in high-risk patients with multiple risk factors for SSI undergoing revision TKA or TKA.											
Curley et al	2018	RCS	32	159	63.4	59.5	NR		NR		Retrospective chart review	16
	A lower infection rate was observed for the ciNPWT patients who had high-risk factors for SSI undergoing primary TKA as opposed to the dry sterile dressing patients, although this difference was not statistically significant.											
Giannini et al	2018	RCT	50	50	66	66.8	62.0	64.0	27.7	28.2	1 week	20
	The results of this study do not support the routine use of ciNPWT following revisional THA or TKA. However, it could be beneficial for selected patients once high-risk factors for wound complications have been determined.											
Gillespie et al	2015	RCT	35	35	63.8	62.5	42.9	51.4	29.9	29.8	6 weeks	21
	A reduction of 3% in SSI incidence suggests that a definitive trial requires approximately 900 patients per group. Yet, there is uncertainty around the benefit of NPWT after primary THA.											
Howell et al	2011	RCT	24	36	NR		NR		NR		Wound: 1 week SSI: 12 months	21
	ciNPWT did not appear to prove lower wound complications in high-risk patients following primary TKA; however, it was associated with blisters.											
Karlakki et al	2016	RCT	102	107	69	69.2	52.0	48.6	30.1	28.4	6 weeks	23
	ciNPWT has a beneficial role in patients undergoing primary THA or TKA to minimise wound complications.											
Keeney et al	2019	RCT	185	213	60.6	60.5	60.5	57.3	34.6	36.5	Wound: 12 weeks SSI: 24 months	20
	ciNPWT improved wound complication rates compared with conventional dressings in patients following primary or revisional THA or TKA; however, SSI rate was not significant difference. Patients with a body mass index >35 kg/m^2 showed to be more susceptible to wound complications. Specific study in this high-risk patient group may be helpful to define the value of iNPWT.											
Manoharan et al	2016	RCT	21	36	66		42.4		29.8		1.5 weeks	17
	There was no benefit in wound healing or cost with NPWT post-TKA. There was some benefit in ciNPWT on quality of life factors less wound leakage and better protection.											
Newman et al	2019	RCT	79	80	65	65	49.4	43.8	33.4	33.4	12 weeks	24
	ciNPWT may decrease the rate of postoperative wound complications in patients who are at an increased risk of such wound issues after revision THA or TKA.											
Pachowsky et al	2012	RCT	9	10	66.2	70.5	NR		NR		1.5 weeks	18
	There was a decreased development of postoperative seromas in the wound and improved wound healing in patients who used ciNPWT following primary THA.											

TABLE 1 (Continued)

Author	Year	Study type	Sample size (n)		Mean age (years)		Percentage of female		BMI (kg/m^2)		Follow-up	MINORS score
			ciNPWT	Control	ciNPWT	Control	ciNPWT	Control	ciNPWT	Control		
Redfern et al	2017	RCS	196	400	66.9	66.8	65.8	54.0	30.5	30.9	Wound: 6 weeks SSI: 2 months	21

ciNPWT for THA and TKA in a comprehensive patient population reduced overall incidence of wound complication, but did not significantly impact the rate of SSI.

[a]BMI, body mass index; ciNPWT, closed incision negative pressure therapy; MINORS, methodological items for non-randomised studies; NR, not reported; RCS, retrospective comparison studies; RCT, randomised controlled trials; SSI, surgical site infection; THA, total hip arthroplasty; TKA, total knee arthroplasty.

included a total of 215 and 433 high-risk patients who received ciNPWT and conventional dressings, respectively. The overall rate of SSI in high-risk patients was significantly lower in the ciNPWT group than in the conventional dressings, and the summary OR was 0.24 (95% CI = 0.09-0.64; $P = .005$) (Figure 2B).

4.4 | Primary arthroplasty vs revision arthroplasty

In terms of wound complication, there were 8 studies with a total of 561 and 955 patients who received ciNPWT and conventional dressings, respectively, following primary arthroplasty. The overall wound complication rate in primary arthroplasty was not significantly different between the ciNPWT and the conventional dressings (OR = 0.59; 95% CI = 0.25-1.40; $P = 0.23$). Three studies included a total of 152 and 229 patients for wound complication who received ciNPWT and conventional dressings, respectively, after revision arthroplasty. The overall wound complication rate in revision arthroplasty was significantly lower in the ciNPWT group than in the conventional dressings, and the summary OR was 0.33 (95% CI = 0.18-0.62; $P < .001$) (Figure 3A). In terms of SSI, there were 7 studies with a total of 552 and 945 patients who received ciNPWT and conventional dressings, respectively, following primary arthroplasty. The overall rate of SSI in primary arthroplasty was not significantly different between the ciNPWT and the conventional dressings (OR = 0.54; 95% CI = 0.26-1.12; $P = .10$). Four studies included a total of 202 and 279 patients who received ciNPWT and conventional dressings, respectively, following revision arthroplasty. The overall rate of SSI in revision arthroplasty was significantly lower in the ciNPWT group than in the conventional dressings, and the summary OR was 0.26 (95% CI = 0.11-0.66; $P = .004$) (Figure 3B).

4.5 | Meta-regression analysis

The results of the meta-regression analyses are shown in Table 3. Patient characteristics including age, sex, and follow-up were not significantly associated with the rates of wound complication and SSI.

5 | DISCUSSION

Recent studies, differing in indications of surgical or patient risk factor, have reported outcomes of ciNPWT after THA or TKA. Although most outcomes were shown

TABLE 2 Summary of closed incision negative-pressure therapy, conventional wound dressings, and details of study indication[a]

		ciNPWT		Conventional wound dressings		Indication	
Author	**Year**	**Material**	**Duration (day)**	**Material**	**Dressing changes**	**Surgery indication**	**Patients indication**
Cooper and Bas	2016	Prevena (125 mm Hg, continuous)	9.2	AQUACEL Ag	Leave the dressing for a minimum of first 5 days	Revision THA or TKA	High-risk factors for SSI: morbid obesity, multiple significant medical or social comorbidities, treatment of an infected joint arthroplasty, and wound closure under tension.
Curley et al	2018	Prevena (125 mm Hg, continuous)	7	Standard sterile gauze dressing	Depending on the wound leakage	Primary TKA	High-risk factors for SSI: increased body mass index, smoking status, history of infection, and numerous comorbidities.
Giannini et al	2018	PICO (80 mm Hg, continuous)	7	Povidone-iodine gauze dressing	Depending on the wound leakage	Revision THA or TKA	High-risk factors for SSI (at least one risk factor): Age > 65 years, diabetes, smoking, obesity (BMI ≥30 kg/m^2), hypertension, pulmonary disease, and vascular disease.
Gillespie et al	2015	PICO (80 mm Hg, continuous)	5	Hydrocolloid dressing	Depending on the wound leakage	Primary THA	Routine application to patients following arthroplasty.
Howell et al	2011	VAC (125 mm Hg, continuous)	2	Standard sterile gauze dressing	Leave the dressing on the second postoperative day	Primary TKA	High-risk factors for SSI: Obesity (BMI >30 kg/m^2) and enoxaparin sodium for deep venous thrombosis prophylaxis.
Karlakki et al	2016	PICO (80 mm Hg, continuous)	7	Mepore or Tegaderm	Mean days of dressing were 4.2	Primary THA or TKA	Routine application to patients following arthroplasty.
Keeney et al	2019	PICO (80 ± 20 mm Hg, continuous)	7	Standard sterile gauze dressing	Subsequent dressing changes every 3 to 5 days	Primary or revision THA or TKA	Routine application to patients following arthroplasty.
Manoharan et al	2016	Prevena (125 mm Hg, continuous)	8	Standard sterile gauze dressing	Dressing changes on day 1 postoperatively	Primary TKA	Routine application to patients following arthroplasty.
Newman et al	2019	Prevena (125 mm Hg, continuous)	≥2	AQUACEL Ag	Dressing for 7 days	Revision THA or TKA	High-risk factors for SSI: Obesity (BMI >35 kg/m^2), use of anticoagulants other than aspirin, peripheral vascular disease, depression, diabetes mellitus, current smoker, history of a PJI in the limb undergoing revision

TABLE 2 (Continued)

Author	Year	ciNPWT		Conventional wound dressings		Indication	
		Material	Duration (day)	Material	Dressing changes	Surgery indication	Patients indication
							surgery, on immunomodulators or corticosteroids, current history of cancer or haematological malignancy, inflammatory arthritis, renal failure or dialysis, malnutrition, liver disease, history of organ transplant, or HIV infection.
Pachowsky et al	2012	Prevena (125 mm Hg, continuous)	5	Standard sterile gauze dressing	Standard dressing changes	Primary THA	Routine application to patients following arthroplasty.
Redfern et al	2017	Prevena (125 mm Hg, continuous)	7.1	Standard sterile gauze dressing	Standard dressing changes	Primary THA or TKA	Routine application to patients following arthroplasty.

[a]BMI, body mass index; ciNPWT, closed-incisional negative-pressure wound therapy; HIV, human immunodeficiency virus; PJI, periprosthetic joint infection; SSI, surgical site infection; THA, total hip arthroplasty; TKA, total knee arthroplasty.

to be effective, the application of ciNPWT to all postoperative wounds would lead to considerable economic burden. Therefore, we performed this systematic review and meta-analysis to assess the effective indications for ciNPWT in wound management following THA or TKA. The most important findings of this study are that wound complication and SSI were significantly less likely to occur in high-risk patients or in revision arthroplasties using ciNPWT compared with conventional dressings. Conversely, there were no significant differences of wound complication and SSI in routine patients or in primary arthroplasties between ciNPWT and conventional dressings.

The number of the arthroplasties is expected to increase dramatically with the ageing population of late,[26] and the ageing population is likely to have several comorbidities. Patients with comorbidities have been shown to increase the risk of both SSC and PJI[2,6,27]; thus, accurate risk stratification of patients for SSC and PJI following THA or TKA is essential. Bozic et al[28] identified specific patient comorbidities such as rheumatoid disease, obesity, coagulopathy, and preoperative anaemia that were independently associated with an increased risk of PJI following THA. Namba et al[27] analysed 56 216 TKAs and demonstrated obesity, diabetes mellitus, male sex, American Society of Anesthesiologists score of $\geq$3, and posttraumatic arthritis are patient factors associated with PJI. Furthermore, several studies have similarly shown that comorbidities associated with immune deficiency, such as renal, rheumatologic, and liver disease, are related with SSC and PJI.[2,29-31] Although many studies have sought to identify risk factors for SSC and PJI, there are relatively little studies that have suggested a method to reduce SSC and PJI in patients having those risk factors, except for controlling or compensating for the comorbidities. Thus, the results of our study indicate that ciNPWT could be a new solution for reducing the wound complication and SSI risk in high-risk patients with comorbidity after THA or TKA.

The prevalence of revision THA and TKA have been increasing with time as primary arthroplasties that have been performed in the past decades require revision and the surgical indications for primary arthroplasties had been broadened recently.[10,14,26,32] Compared with primary arthroplasties, the revision procedure of THA or TKA requires a longer surgical time, has a longer surgical incision and results in more difficult wound healing because of the previous scar, which frequently causes SSC and consequently increases the risk of PJI.[2,4,10,18,33] Many studies have identified that the revision procedure is one of the most crucial risk factors for SSC and PJI after THA or TKA, resulting in poorer clinical outcomes, longer hospital

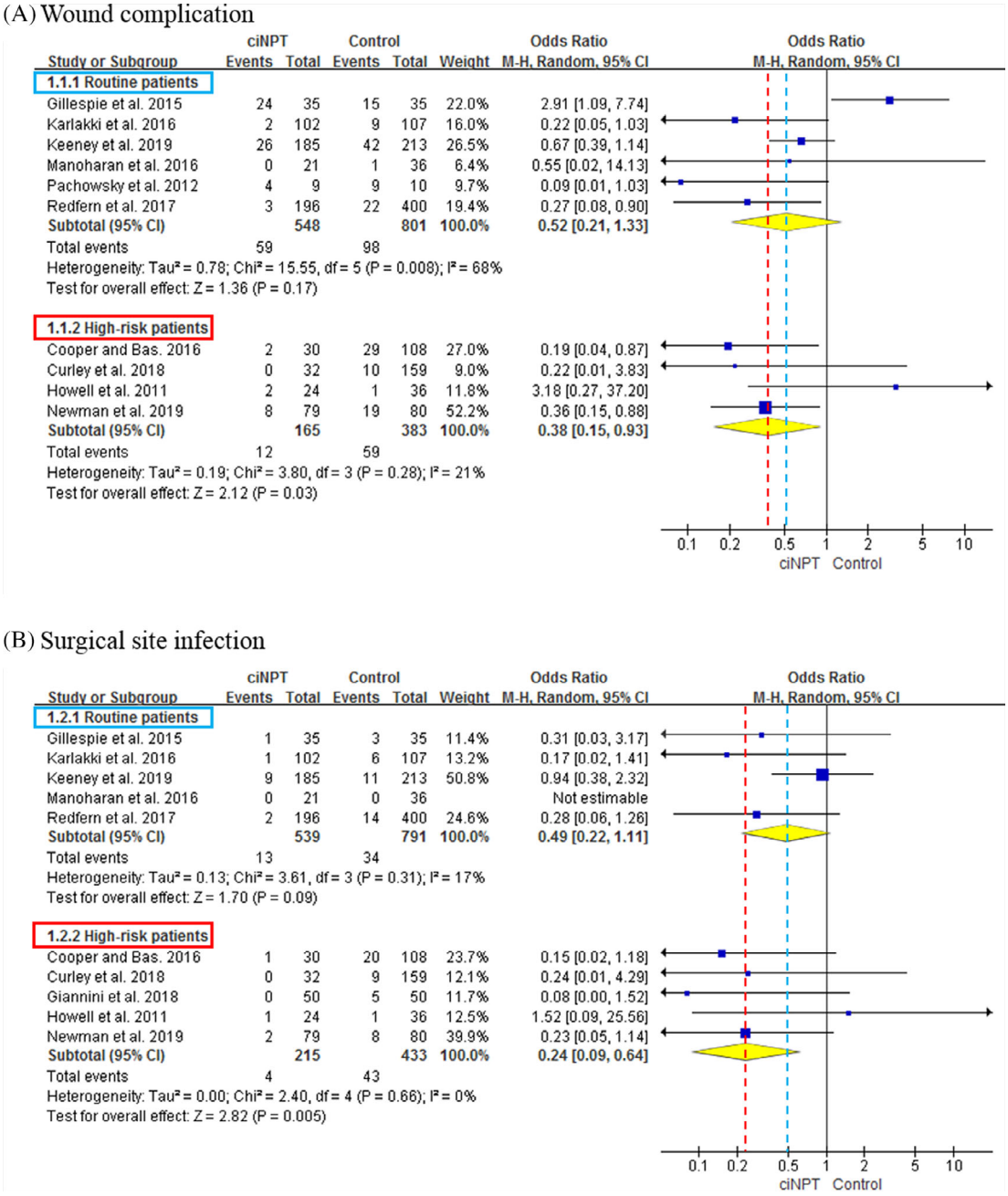

FIGURE 2 Forest plots showing the overall rates of wound complication, A, and surgical site infection (SSI), B, between the ciNPWT and control groups in routine patients and high-risk patients. In routine patients, there were no differences in the rates of wound complication and SSI between the two groups. However, in high-risk patients, the overall rates of wound complication (odds ratio [OR] = 0.38; 95% CI = 0.15-0.93; $P = .03$) and SSI (OR = 0.24; 95% CI = 0.09-0.64; $P = .005$) were significantly lower in the ciNPWT group. ciNPWT, closed-incisional negative-pressure wound therapy

stay, and greater economic burden.[1,2,28,34-36] Although several attempts to decrease the infection risk during the revision procedure have been shown such as using antibiotic-laden cement, an irrigation solution of antibiotics, and prophylactic antibiotics, the efficacy of those attempts remains unclear.[27,37,38] Given wound-related complications are a great concern for revision arthroplasty, our results identified that ciNPWT significantly reduced wound complication and SSI in revision THA or TKA compared with conventional dressings.

Increasingly, ciNPWT systems have been applied to high-risk wounds in various fields and showed a notable efficacy of reducing SSC.[39-42] Specific to patients following THA or TKA in our study, the use of ciNPWT

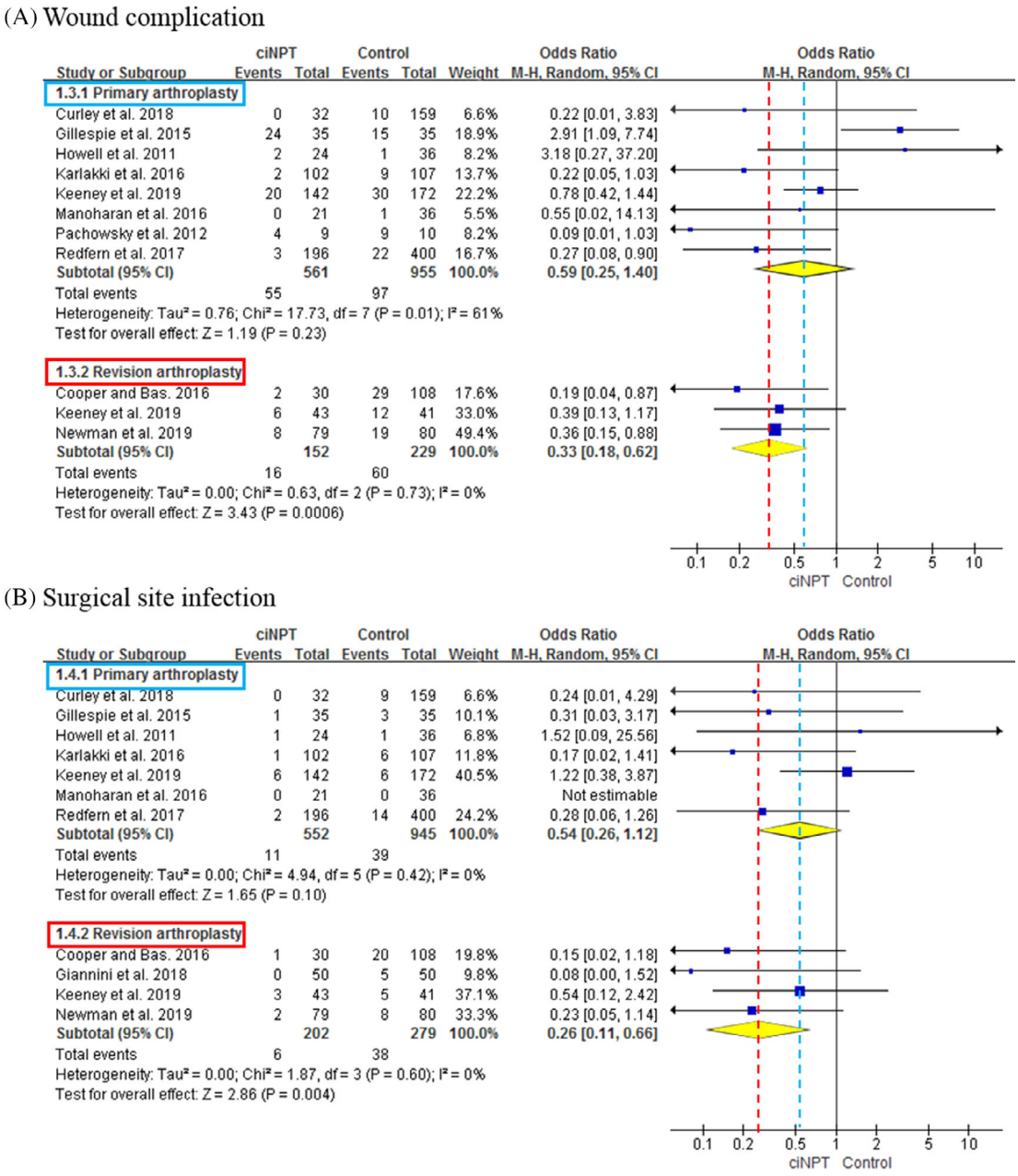

FIGURE 3 Forest plots showing the overall rates of wound complication, A, and surgical site infection (SSI), B, between the ciNPWT and control groups in primary arthroplasty and revision arthroplasty. In primary arthroplasty, there were no differences in the rates of wound complication and SSI between the two groups. However, in revision arthroplasty; the overall rates of wound complication (odd ratio [OR] = 0.33; 95% CI = 0.18-0.62; $P < .001$) and SSI (OR = 0.26; 95% CI = 0.11-0.66; $P = .004$) were significantly lower in the ciNPWT group. ciNPWT, closed-incisional negative-pressure wound therapy

similarly showed significantly lower rates of wound complication and SSI in high-risk patients and in revision arthroplasties than with conventional dressings. Clearly, ciNPWT offers several potential benefits to improve wound healing and prevent SSI of closed surgical incisions. One important explanation may be a reduction of the relative motion on incisional edges by mechanical stabilisation.[43,44] Another explanation includes reducing dead space, subcutaneous hematoma, and seroma, and improving perfusion and lymphatic flow, all of which contribute to a better environment for wound healing.[23,44,45] Other explanations may include that ciNPWT keeps surgical wounds sterile in the role of a mechanical barrier and requires fewer dressing changes and a longer duration from the initial application.[10,46-48]

We acknowledge several limitations of this study. The heterogeneity of the demographic data among included studies, including differences in age, sex distribution, as

TABLE 3 Meta-regression analysis for the assessment of the influence of age, percentage of female, body mass index, and follow-up period on the wound complication and surgical site infection[a]

Variable	Coefficient	SE	*P* value	95% CI
Wound complication				
Age	−0.254	0.158	.107	−0.564 to 0.055
Percentage of female	−0.112	0.122	.360	−0.352 to 0.128
Follow-up (week)	−0.091	0.265	.731	−0.611 to 0.429
Surgical site infection				
Age	−0.197	0.174	.257	−0.539 to 0.144
Percentage of female	−0.084	0.103	.412	−0.285 to 0.117
Follow-up (month)	0.089	0.095	.349	−0.097 to 0.274

[a]BMI, body mass index; CI, confidence interval.

well as differences in follow-up duration, may be potential confounding factors. However, our meta-regression analysis showed that age, sex distribution, BMI, and follow-up were not significantly associated with rates of wound complication and SSI. Although surveillance for the first 12 months after THA and TKA is recommended,[49,50] only three included studies[3,10,20] had more than 12 months of follow-up. However, wound-related SSI is likely to occur in the acute setting[51] and a follow-up duration of less than 12 months might be acceptable to evaluate the efficacy of the ciNPWT system on wound management. Second, studies differing in the indication of patient comorbidities might include selection bias. Although a small difference in the specific indication of comorbidities might be a potential selection bias, the details of the indication had a similarity among the included studies of high-risk patients according to Table 2. Third, included studies were fewer in subgroups of high-risk patients and revision arthroplasty than in the subgroups of routine patients and primary arthroplasty, which might include confounding factors. However, the present study has a strength as the first systematic review and meta-analysis regarding this topic because ciNPWT has recently started to be administered to patients undergoing THA or TKA. Finally, we could not perform a cost-effectiveness analysis of the ciNPWT system because of a lack of published studies.

In conclusion, the current study showed that the application of ciNPWT reduced the incidence of wound complication and SSI in high-risk patients and in revision procedures after THA or TKA compared with conventional dressings. Our findings suggest that ciNPWT should be considered for high-risk patients and in revision procedures for wound management following THA or TKA.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ETHICAL APPROVAL

This article does not contain any studies with human participants or animals performed by any of the authors.

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