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# Closed Incision Negative-Pressure Therapy on Free Flap Donor Sites: A Meta-analysis of Postoperative Outcomes

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**Background:** Closed incision negative-pressure therapy (ciNPT) has become increasingly used on surgical sites to attempt to minimize postoperative complications. The literature describing the benefits of ciNPT in reducing donor site morbidity after free tissue transfer is limited. This review compares the effectiveness of ciNPT and conventional dressings in reducing donor site complications after free tissue transfer.

**Methods:** A systematic review of PubMed and Ovid (MEDLINE) utilizing the search terms ((flap) AND (donor)) AND ((negative pressure) OR (vacuum)) was conducted. Bibliographies of selected articles were also searched. Relevant outcomes were collected and analyzed.

**Results:** After screening 156 articles, 12 studies were included in the study with a total of 1074 donor sites. The following postoperative complications at the donor site after a free tissue transfer were analyzed: wound dehiscence, infection, seroma, hematoma, and skin necrosis. Use of ciNPT was associated with lower incidence of wound dehiscence compared with conventional dressings (OR: 0.37; 95% CI, 0.23–0.58). The incidence of infection, seroma, hematoma, and skin necrosis were overall lower in the ciNPT group; although, this was not statistically significant.

**Conclusions:** Use of ciNPT was associated with a significantly lower incidence of free flap donor site wound dehiscence compared with conventional dressings. The use of ciNPT on free flap donor sites appears to have overall lower rates of other wound complications such as seroma, hematoma, skin necrosis, and infection.
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## INTRODUCTION

Free tissue transfer is one of several methods of reconstructing soft tissue defects. Appropriate management of the donor site after free tissue transfer is imperative to minimize morbidity. In best-case scenarios, donor sites can be closed primarily with minimal tension. However, in cases of larger flap harvest and higher tension donor site closures, different methods have been used to offset potential complications after these primary closures. Closed incision negative pressure therapy (ciNPT) is a potential alternative to conventional dressings for management of free flap donor sites.[1,2] Although traditionally applied to open wounds, negative-pressure wound therapy has been used in management of surgical wounds and has been associated with a decreased risk of surgical site infection.[3,4] Negative-pressure wound therapy accelerates wound healing through promotion of blood flow, expression of growth factors, and removing excess fluid while maintaining a closed environment that holds the wound edges together.[5,6] Results of studies investigating use of ciNPT for primarily closed free flap donor sites have been mixed. Our study aimed to compare outcomes of free flap donor sites managed with ciNPT to those managed with conventional dressings.

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Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

## METHODS

### Search Methodology

A systematic review of literature was performed using PubMed and Ovid databases, using the following search terms: ((flap) AND (donor)) AND ((negative pressure) OR (vacuum)). Bibliographies were also searched in the extracted articles. This search and subsequent analysis were performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[7] Two researchers initially screened all abstracts and then selected eligible studies based on full-text review.

### Selection Criteria

Abstracts and titles were initially screened, and non-English and nonhuman studies that were retrieved were immediately excluded. Full-text articles were then assessed for eligibility; conference and abstract presentations, editorials, narratives, commentaries, opinions, and case reports were excluded. Studies that directly compared outcomes between use of ciNPT and use of conventional dressings for free flap donor site wound management were included.

### Statistical Analysis

Outcomes from included studies were collected and reported as odds ratios. The following outcomes were analyzed: wound dehiscence, seroma, hematoma, infection, and necrosis. Meta-analysis using DerSimonian-Laird random-effects model was performed to synthesize the extracted outcome data into single odds ratios with 95% CI. $I^2$ statistic values were calculated for each outcome to quantify level of heterogeneity among the studies. Publication bias and small study effects were explored using funnel plots and the Egger linear regression method. Sensitivity analysis was also performed to assess differences in donor site location. All statistical data analysis was performed using Stata version 17 (StataCorp, College Station, Tex.).

## RESULTS

### Included Studies

The electronic search yielded a total of 156 studies. Of these, 12 studies met criteria for inclusion in the study (Fig. 1). Seven of the included studies were retrospective cohort studies, two were retrospective case-control studies, two were case series, and one was a randomized control trial. Seven of the studies investigated abdominal donor sites;[8–14] two of these investigated anterolateral thigh donor sites,[15,16] two investigated medial thigh donor sites,[17,18] and one investigated posterior trunk donor sites.[19] In regard to the reconstructed area, the majority (nine studies) investigated free tissue transfer to the breast. In total, 1074 patients were included in the study: 489 received ciNPT for management of their donor sites, and 585 received standard dressings. Supplemental Table 1 summarizes the characteristics of each study. (**See table, Supplemental Digital Content 1,** which displays a summary of included studies. **http://links.lww.com/PRSGO/D359**.)

### Takeaways

**Question:** Are there less postoperative donor site complications after free tissue transfer when using closed incision negative-pressure therapy?

**Findings:** After screening 156 articles, 12 studies were included in the meta-analysis with a total of 1074 donor sites. Closed incision negative-pressure therapy (ciNPT) had a significantly lower incidence of wound dehiscence compared with conventional dressings. Additionally, the incidence of infection, seroma, hematoma, and skin necrosis were overall lower with the use of ciNPT (although not statistically significant).

**Meaning:** Using ciNPT on donor sites will likely decrease the incidence of wound dehiscence in patients who undergo free tissue transfer.

### Outcomes

Eleven of the studies compared the incidence of dehiscence between ciNPT and standard dressings. Use of ciNPT for free flap donor sites was associated with a lower incidence of dehiscence than standard dressings (OR: 0.37; 95% CI, 0.23–0.58; Fig. 2). Nine studies reported incidence of seroma between cohorts, and there was no statistically significant difference between the two groups (OR: 0.60; 95% CI, 0.28–1.30; Fig. 3). Six studies reported incidence of hematoma between cohorts, and there was no statistically significant difference found when comparing the two groups (OR: 0.78; 95% CI, 0.27–2.25; Fig. 4). Ten studies reported incidence of infection between cohorts, and there was no statistically significant difference between the two (OR: 0.66; 95% CI, 0.35–1.27; Fig. 5). Four studies reported incidence of necrosis between cohorts, and there was no statistically significant difference between the two groups (OR: 0.66; 95% CI, 0.22–1.85; Fig. 6). Statistical heterogeneity was low across studies for each analysis performed (range: 0.00%–22.50%).

### Assessment of Bias and Sensitivity Analysis

Selection bias is present in at least four of the included studies, as the authors acknowledge using ciNPT for wounds they deemed "high-risk,"[14] or the authors switched their dressings after a certain time-point due to their clinical experiences.[16–18] Funnel plots were performed for each outcome analysis to test for publication bias. (**See figure, Supplemental Digital Content 2,** which displays funnel plots of standard error by log odds ratio assessing publication bias for the meta-analyses performed. **http://links.lww.com/PRSGO/D360**.)

No significant asymmetry is seen in any of these plots. Egger test for small study effects bias was also performed for each outcome analysis. This was not significant. Finally, sensitivity analysis was performed to assess differences in outcomes based on donor site location. No significant differences in outcomes were noted between locations.

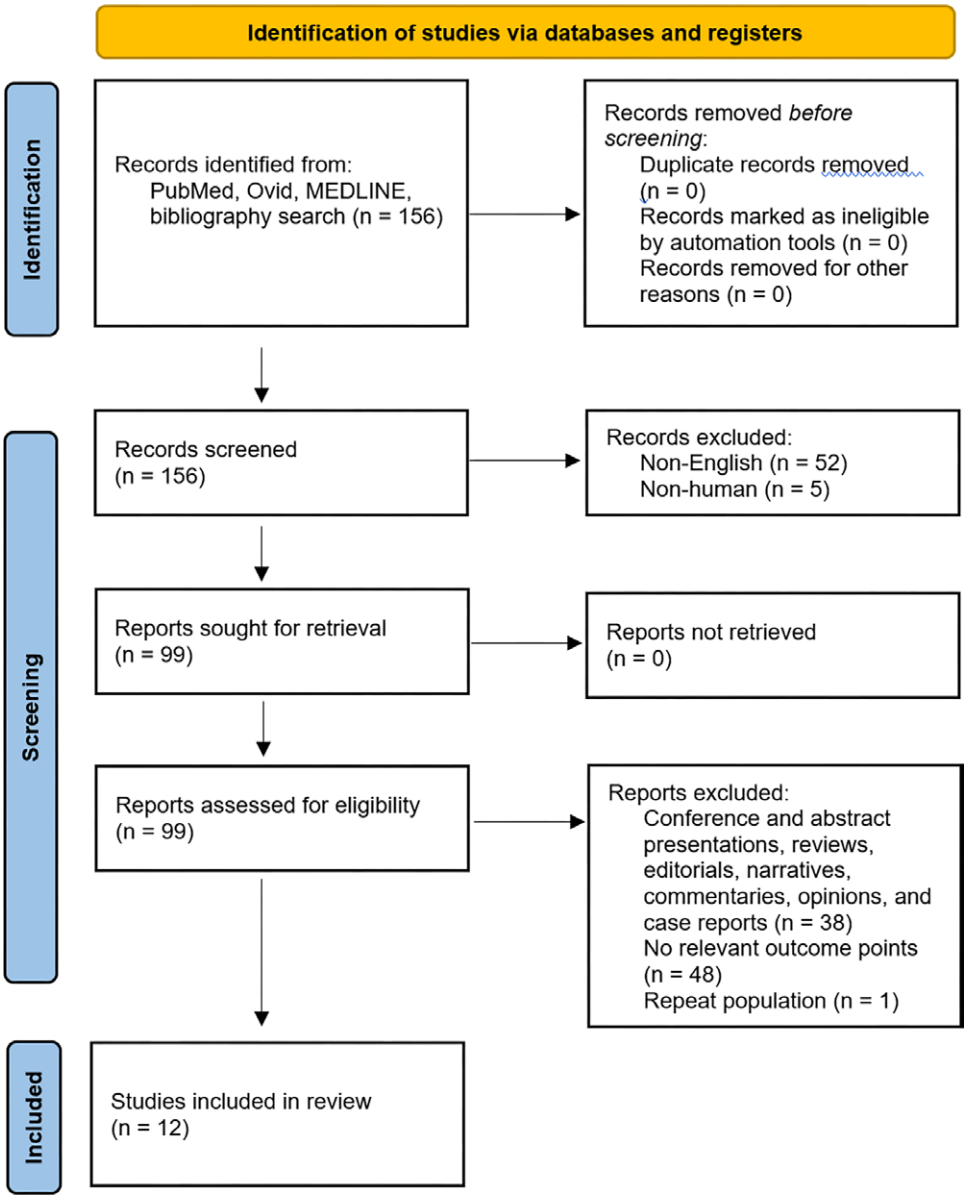


**Fig. 1.** PRISMA flow chart illustrating the results of the systematic review.

## DISCUSSION

Conventional dressings are less occlusive and do not adhere as tightly to the incision as ciNPT dressings, resulting in decreased hydration of the area, which may contribute to delayed wound healing and more postoperative complications. Based on the results of our analysis, the use of ciNPT in management of free flap donor site wounds is associated with a decreased rate of wound dehiscence compared with management with standard dressings. Similar to our study, a meta-analysis reviewing studies that investigated use of ciNPT in abdominal wall reconstruction wound management also found lower incidence of wound dehiscence when compared with conventional dressings.[20] No difference in incidence of seroma or hematoma was found either, as in our study. However, one randomized controlled study focusing on ciNPT for immediate alloplastic breast reconstruction found a decreased incidence of seroma compared with standard dressings.[21] Drains were left in place in the donor site in most of our included studies, but only four studies reported the average time these drains remained in their patients.[10,12,13,18] All four of these studies reported no significant difference in time to drain removal when comparing their ciNPT group and conventional dressings group. In the studies that reported drain output as a measure, there was no difference between the two groups as well.[9,10,12,18] Subsequently, in addition to likely not having an effect on seroma or hematoma rates, ciNPT was also not associated with a shorter time to drain removal in our study.

Although our meta-analysis did not find a statistically significant decrease in infection rates when using ciNPT, several other studies did find that ciNPT was associated

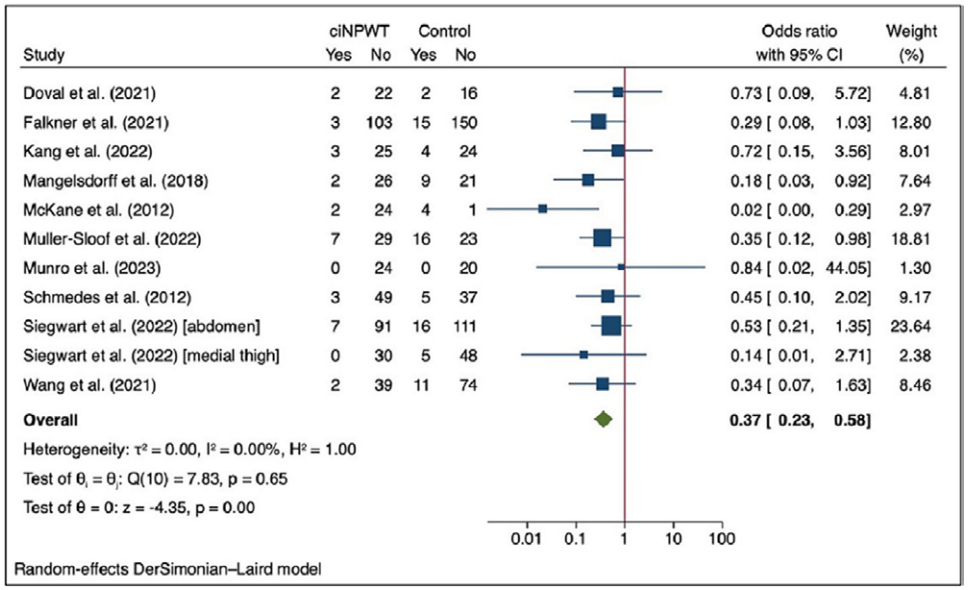


**Fig. 2.** Results from meta-analysis comparing incidence of wound dehiscence between ciNPT and conventional dressings for management of free flap donor sites.

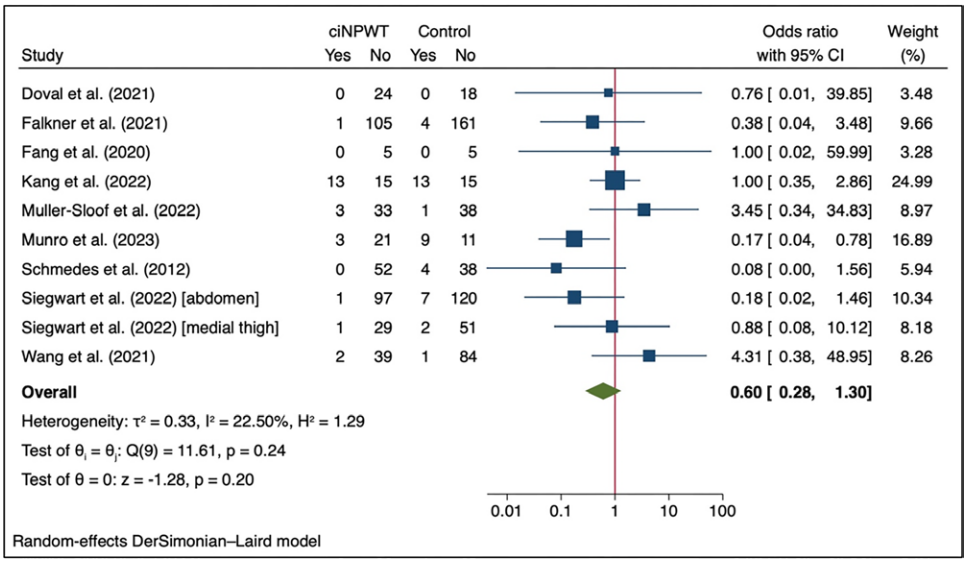


**Fig. 3.** Results from meta-analysis comparing incidence of seroma between ciNPT and conventional dressings for management of free flap donor sites.

with a lower incidence of infection.[3,4,20] An overall decrease in surgical site infections was also seen in a recent meta-analysis of the use of ciNPT in ventral hernia repairs.[21] Another meta-analysis that looked at the use of ciNPT in all general surgery and colorectal surgery laparotomy incisions also found a decrease in infection compared with conventional dressings.[22] Additionally, ciNPT has also been shown to reduce surgical site infections (both superficial and deep) in orthopedic surgery.[23,24] This has largely been attributed to the closed environment the ciNPT dressing provides and the increase in microcirculation due to the negative-pressure therapy.[21–24] In our study, no significant difference was found in incidence of infection or necrosis between standard dressings and ciNPT. This remained true even when controlling for donor site location. While our study failed to find a statistically significant difference in incidence of infection between ciNPT and conventional dressings when used for free flap donor site management, only one of the ten studies that included outcomes for donor site infection showed a lower incidence of infection in the ciNPT group, and all ten failed to find any statistically significant difference. This may represent type 2 error due to inadequate powering given the trend of lower incidence of infection in the ciNPT

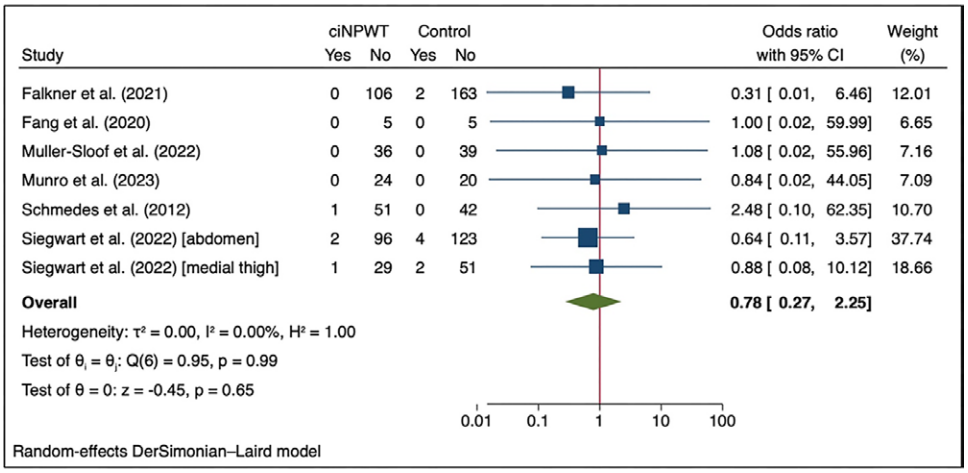


**Fig. 4.** Results from meta-analysis comparing incidence of hematoma between ciNPT and conventional dressings for management of free flap donor sites.

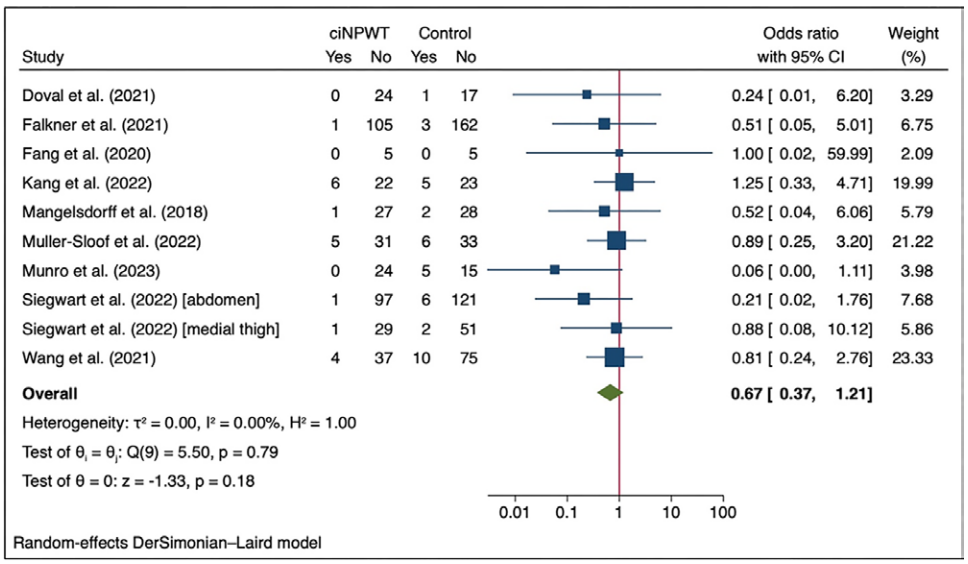


**Fig. 5.** Results from meta-analysis comparing incidence of infection between ciNPT and conventional dressings for management of free flap donor sites.

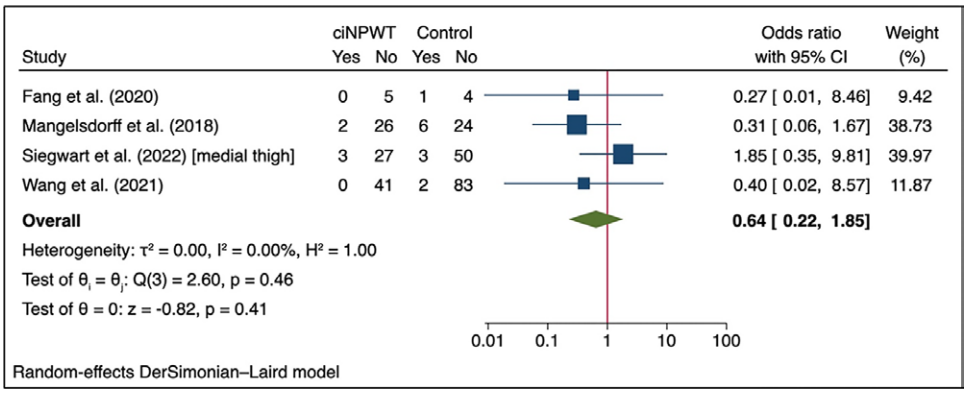


**Fig. 6.** Results from meta-analysis comparing incidence of necrosis between ciNPT and conventional dressings for management of free flap donor sites.

groups, suggesting that a difference may be found given a larger sample size. On the other hand, free flap donor sites are deemed "clean," whereas other general/colorectal surgery studies' laparotomy incisions are considered "clean-contaminated" or "contaminated" depending on the procedure so inherently less surgical site infections would occur in our studied population.

Although the mechanisms by which negative-pressure therapy facilitates healing for open wounds have been well described in the literature, the biomechanics of ciNPT are still being explored. To reiterate, ciNPT dressings are more occlusive than conventional dressings, creating a closed, more hydrated environment for the incision. It also decreases relative motion shearing of the incision and reduces lateral tension or stress perpendicular to the incision.[23,24] Muenchow et al found a significant increase in skin microcirculation via a technique combining tissue laser and photospectrometry when negative-pressure dressings were applied to a closed incision.[25] Pieszko et al discovered that scar was more elastic after one year with ciNPT compared with standard dressings in a randomized controlled trial for immediate implant-based breast reconstruction patients.[26] Based on our results and previous studies' conclusions, these physiologic findings likely translate clinically, as ciNPT has been associated with decreased complications and improved scarring.

Although ciNPT may show promise in surgical site management, the surgeon may still choose conventional dressings for various reasons. For example, standard dressings may be selected due to availability and cost. At our institution, standard gauze, adhesive strips, and tape are not charged directly to the patient, but ciNPT dressings are. On the other hand, ciNPT dressings are less of a burden on providers and nursing staff, requiring less frequent changes (if they are to be changed at all because some surgeons prefer removal after a certain number of days and then leaving the incision open to air). This is a particular advantage of ciNPT when the donor site is in a difficult anatomical area to perform frequent dressing changes (ie, the medial thigh), especially in obese patients. Furthermore, surgeons may preferentially elect to use ciNPT on wounds they consider "high-risk." One of our included studies (Wang et al)[14] applied ciNPT dressings on "patients who were considered to be at 'high risk' of poor wound healing." In particular, patients "with diabetes and/or obesity were preferentially selected to trial the ciNPT dressing" in their study.[14] One other study in our analysis [Siegwart et al (abdomen)][13] also was more likely to use ciNPT in patients with higher BMIs. All other studies reported no significant demographic differences between their compared groups.

We do acknowledge several limitations in our meta-analysis. First, the studies used for this review have relatively small sample sizes, which can result in inadequate powering. In addition to being unable to detect meaningful differences between cohorts, the small sample sizes may also result in slight differences in populations being amplified. Second, the studies used were primarily retrospective in nature, predisposing the results to potential confounding factors and bias. Only one randomized control trial was included. Moreover, most of our included studies investigate the use of ciNPT in free tissue transfer for breast reconstruction. There are also innate differences anatomically and physiologically in these donor sites that are being compared in this study (ie, the abdomen versus medial thigh). Even within the same anatomical donor site, there are differences in how the flap is harvested, which may affect outcomes (ie, which perforators were selected, how many perforators were taken, was fascia taken, etc). Unfortunately, we were not able to compare that data among the studies included and were limited to the data provided. Additional limitations of our meta-analysis include the various dressings in the control groups, different closure techniques, and varying number of drains used. Finally, with any meta-analysis comes inherent selection bias and variability among studies. Steps were, however, taken to detect this potential bias through calculating heterogeneity among studies, creation of funnel plots, and performing Egger test for small study effects.

## CONCLUSIONS

The results of our meta-analysis suggest that use of ciNPT for free flap donor sites decreases postoperative complications. Use of ciNPT is associated with lower incidence of wound dehiscence when compared with conventional standard dressings. Incidences of seroma, hematoma, infection, or necrosis were also lower for ciNPT, but these results were not statistically significant. The trends displayed in the included studies suggest that lower incidence of infection with ciNPT may also be found with an adequately powered study.

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## DISCLOSURE

*The authors have no financial interest to declare in relation to the content of this article.*

## REFERENCES

1. Harris BN, Bewley AF. Minimizing free flap donor-site morbidity. *Curr Opin Otolaryngol Head Neck Surg.* 2016;24:447–452.
2. Archibald H, Stanek J, Hamlar D. Free flap donor-site complications and management. *Semin Plast Surg.* 2022;37:26–30.
3. Willy C, Agarwal A, Andersen CA, et al. Closed incision negative pressure therapy: international multidisciplinary consensus recommendations. *Int Wound J.* 2017;14:385–398.
4. Singh DP, Gabriel A, Parvizi J, et al. Meta-analysis of comparative trials evaluating a single-use closed-incision negative-pressure therapy system. *Plast Reconstr Surg.* 2019;143:41S–46S.
5. Xia CY, Yu AX, Qi B, et al. Analysis of blood flow and local expression of angiogenesis-associated growth factors in infected wounds treated with negative pressure wound therapy. *Mol Med Rep.* 2014;9:1749–1754.
6. Zwanenburg PR, Tol BT, de Vries FEE, et al. Incisional negative pressure wound therapy for surgical site infection prophylaxis in the post-antibiotic era. *Surg Infect (Larchmt).* 2018;19:821–830.

7. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71.
8. Doval AF, Chegireddy V, Beal L, et al. Efficacy of closed incision negative pressure wound therapy on abdominal donor site after free flap breast reconstruction. *Wounds*. 2021;33:81–85.
9. Fang CL, Changchien CH, Chen MS, et al. Closed incision negative pressure therapy following abdominoplasty after breast reconstruction with deep inferior epigastric perforator flaps. *Int Wound J*. 2020;17:326–331.
10. Kang S, Okumura S, Maruyama Y, et al. Effect of incision negative pressure wound therapy on donor site morbidity in breast reconstruction with deep inferior epigastric artery perforator flap. *JPRAS Open*. 2022;34:73–81.
11. Muller-Sloof E, de Laat E, Kenç O, et al. Closed-incision negative-pressure therapy reduces donor-site surgical wound dehiscence in DIEP flap breast reconstructions: a randomized clinical trial. *Plast Reconstr Surg*. 2022;150:38S–47S.
12. Munro SP, Dearden A, Joseph M, et al. Reducing donor-site complications in DIEP flap breast reconstruction with closed incisional negative pressure therapy: a cost-benefit analysis. *J Plast Reconstr Aesthet Surg*. 2023;78:13–18.
13. Siegwart LC, Sieber L, Fischer S, et al. Influence of closed incision negative-pressure therapy on abdominal donor-site morbidity in microsurgical breast reconstruction. *Microsurgery*. 2022;42:32–39.
14. Wang J, Chapman Z, Cole E, et al. Use of closed incision negative pressure therapy (ciNPT) in breast reconstruction abdominal free flap donor sites. *J Clin Med*. 2021;10:5176.
15. Falkner F, Thomas B, Mayer S, et al. The impact of closed incisional negative pressure therapy on anterior lateral thigh flap donor site healing and scarring: a retrospective case-control study. *J Plast Reconstr Aesthet Surg*. 2022;75:152–159.
16. Mangelsdorff G, Cuevas P, Rodriguez JR, et al. Reduced anterolateral thigh flap donor-site morbidity using incisional negative pressure therapy. *J Reconstr Microsurg*. 2019;35:229–234.
17. McKane BW, Korn PT. The fleur-de-lis upper gracilis flap for breast reconstruction: flap design and outcome. *Ann Plast Surg*. 2012;69:383–386.
18. Siegwart LC, Tapking C, Diehm YF, et al. The use of closed incision negative pressure therapy on the medial thigh donor site in transverse musculocutaneous gracilis flap breast reconstruction. *J Clin Med*. 2022;11:2887.
19. Schmedes GW, Banks CA, Malin BT, et al. Massive flap donor sites and the role of negative pressure wound therapy. *Otolaryngol Head Neck Surg*. 2012;147:1049–1053.
20. Tran BNN, Johnson AR, Shen C, et al. Closed-incision negative-pressure therapy efficacy in abdominal wall reconstruction in high-risk patients: a meta-analysis. *J Surg Res*. 2019;241:63–71.
21. Guo C, Cheng T, Li J. Prophylactic negative pressure wound therapy for closed laparotomy incisions after ventral hernia repair: a systematic review and meta-analysis. *Int J Surg*. 2022;97:106216.
22. Sahebally SM, McKevitt K, Stephens I, et al. Negative pressure wound therapy for closed laparotomy incisions in general and colorectal surgery. *JAMA Surg*. 2018;153:e183467.
23. Xie W, Dai L, Qi Y, et al. Negative pressure wound therapy compared with conventional wound dressings for closed incisions in orthopaedic trauma surgery: a meta-analysis. *Int Wound J*. 2022;19:1319–1328.
24. Brem MH, Bail HJ, Biber R. Value of incisional negative pressure wound therapy in orthopaedic surgery. *Int Wound J*. 2014;11:3–5.
25. Muenchow S, Horch RE, Dragu A. Effects of topical negative pressure therapy on perfusion and microcirculation of human skin. *Clin Hemorheol Microcirc*. 2019;72:365–374.
26. Pieszko K, Pieszko K, Wichtowski M, et al. A randomized study comparing closed-incision negative-pressure wound therapy with standard care in immediate breast reconstruction. *Plast Reconstr Surg*. 2023;151:1123–1133.