When used as a bridge to definitive closure, does NPWT significantly reduce infection risk compared with saline-soaked gauze dressings?

Background:

Open fractures are associated with substantial soft-tissue injury, contamination, and disruption of local vascularity, placing patients at increased risk of infection, delayed wound healing, nonunion, and limb loss. Meticulous debridement, fracture stabilization, antibiotic administration, and timely soft-tissue coverage remain the cornerstones of management. However, definitive wound closure is often delayed because of contamination, soft-tissue loss, tissue swelling, or the need for repeated debridement.

Negative pressure wound therapy (NPWT) has been increasingly used as a temporary wound management strategy and bridge to definitive soft-tissue coverage in open fractures. By applying controlled subatmospheric pressure to the wound bed, NPWT is proposed to remove excess exudate, reduce edema, improve local perfusion, decrease bacterial burden, stimulate granulation tissue formation, and facilitate wound bed preparation for closure. These potential benefits have led to widespread adoption of NPWT in the management of complex open fracture wounds.

Despite its popularity, the effectiveness of NPWT in reducing infection risk compared with conventional saline-soaked gauze or standard dressings remains controversial. Several clinical studies have reported lower rates of deep infection and osteomyelitis with NPWT, whereas others have demonstrated no significant benefit. In addition, concerns remain regarding the quality of available evidence, heterogeneity of patient populations, variation in wound severity, and differences in outcome definitions across studies.

Given the continued uncertainty regarding the role of NPWT as a bridge to definitive closure in open fractures, a systematic review of the available evidence was undertaken to determine whether NPWT significantly reduces infection risk compared with conventional dressing techniques.

Results:

A total of 10 comparative studies involving 2,596 patients with open fractures were included. The evidence consisted of prospective randomized controlled trials, prospective comparative studies, retrospective cohort studies, and one large propensity-adjusted observational analysis. Most studies evaluated Gustilo-Anderson type III open fractures of the tibia or lower extremity and compared NPWT with saline-soaked gauze dressings, conventional dressings, occlusive dressings, or wet-to-dry dressings.

Among the included studies, six reported significantly lower infection rates with NPWT compared with conventional wound management. Stannard et al. demonstrated a reduction in deep infection from 28% to 5.4% with NPWT. Virani et al. reported lower overall infection rates (4.6% vs 22%) and reduced bacterial colonization in the NPWT group. Sibin et al. observed lower wound infection rates with NPWT (26.7% vs 66.7%). Blum et al. reported significantly lower deep infection rates in open tibial fractures treated with NPWT (8.4% vs 20.6%), with multivariable analysis demonstrating a 78% reduction in infection risk. Joethy et al. reported lower infection rates in Gustilo IIIB tibial fractures treated with NPWT (10% vs 33%). Kumaar et al. demonstrated lower deep infection rates with NPWT compared with saline-soaked dressings (6.3% vs 20.3%).

In contrast, two randomized studies did not demonstrate a significant reduction in infection with NPWT. Arti et al. reported similar infection rates between NPWT and conventional dressings (6.7% vs 8.9%). The WOLLF trial, the largest randomized controlled trial included, found no

significant differences in deep surgical site infection, wound healing, fracture union, functional outcomes, or quality of life between NPWT and standard dressings.

One large observational analysis derived from the FLOW trial reported higher rates of deep infection among patients treated with NPWT. However, the authors noted substantial confounding by indication, as NPWT was preferentially used in more severe injuries.

Several studies also reported favorable secondary wound-related outcomes with NPWT. These included faster granulation tissue formation, greater reductions in wound dimensions, earlier achievement of a wound bed suitable for definitive soft-tissue coverage, reduced frequency of dressing changes, and shorter durations of hospitalization. However, these outcomes were not consistently assessed across studies and were reported using heterogeneous measures.

S. No	Author, Year	Study Design	Sample Size	Population	Comparison	Infection Outcome	Key Findings	Risk of Bias
1	Stannard et al., 2009	Prospective randomized trial	59 open fractures	Severe open fractures requiring delayed closure	NPWT vs fine mesh gauze dressing	Deep infection	Deep infection: 5.4% vs 28%; RR 0.20; p=0.024	Moderate
2	Blum et al., 2012	Retrospective cohort	229 open tibial fractures	Open tibial fractures	NPWT vs conventional dressing	Deep infection	Deep infection significantly lower with NPWT; adjusted OR 0.22 (95% CI 0.09–0.55); p=0.001	Moderate–High
3	Joethy et al., 2013	Retrospective comparative cohort	69 Gustilo IIIB tibial fractures	Gustilo IIIB fractures requiring flap reconstruction	NPWT vs occlusive dressing	Infection	Infection: 10% vs 33%; p=0.0288	High
4	Rezzadeh et al., 2015	Retrospective comparative cohort	32 Gustilo IIIB/IIIC tibial fractures	Severe open tibial fractures requiring free flap reconstruction	NPWT vs wet-to-dry dressing	SSI/Osteomyelitis	Lower SSI and osteomyelitis rates with NPWT; fewer complications overall	High
5	Virani et al., 2016	Prospective randomized trial	93 open tibial fractures	Predominantly Gustilo IIIA/IIIB fractures	NPWT vs daily dressing/debridement	Acute and deep infection	Infection: 4.6% vs 22%; RR 5.5; p<0.05	Moderate
6	Arti et al., 2016	Prospective randomized trial	90 Gustilo IIIB fractures	Gustilo IIIB open fractures	NPWT vs conventional dressing	Infection	Infection: 6.7% vs 8.9%; p=0.6 (no significant difference)	Moderate

7	Sibin et al., 2017	Prospective randomized study	30 Grade III tibial fractures	Gustilo IIIA/IIIB tibial fractures	NPWT vs sterile dressing	Wound infection	Infection: 26.7% vs 66.7%; p=0.028	Moderate–High
8	Costa et al. (WOLLF), 2018	Multicentre randomized controlled trial	460 severe open lower limb fractures	Severe open lower-limb fractures	NPWT vs standard dressing	Deep SSI	Deep SSI: 7.1% vs 8.1%; no significant difference	Low
9	Kumaar et al., 2022	Prospective comparative study	Open lower-limb fractures	Gustilo III open fractures	NPWT vs conventional dressing	Infection	Lower infection rates and improved wound healing with NPWT	Moderate
10	Atwan et al. (FLOW secondary analysis), 2022	Propensity-adjusted observational study	1322 open fractures	Gustilo II and III lower-limb fractures	NPWT vs standard dressing	Deep infection requiring surgery	Deep infection: 18.8% vs 6.3%; adjusted OR 4.52 (95% CI 1.84–11.12); p=0.001	High

Risk of Bias Table

Study	**ROB**
Stannard	Moderate
Blum	Moderate-High
Joethy	High

Rezzadeh	High
Virani	Moderate
Arti	Moderate
Sibin	Moderate-High
WOLLF	Low
Kumaar	Moderate
Atwan	High

Results Summary Table

Study	NPWT Better	No Difference	NPWT Worse
Stannard	✓		
Blum	✓		
Joethy	✓		
Rezzadeh	✓		
Virani	✓		
Arti		✓	
Sibin	✓		
WOLLF		✓	
Kumaar	✓		
Atwan			✓

Discussion:

The present review evaluated the available evidence regarding the use of negative pressure wound therapy (NPWT) as a bridge to definitive closure in open fractures and its effect on infection risk compared with conventional dressings. Overall, most comparative studies reported lower infection rates with NPWT. However, the magnitude and consistency of this benefit varied across studies, and the highest-quality evidence did not demonstrate a significant reduction in infection. These

findings suggest that although NPWT may offer advantages in wound management, its role in preventing infection remains uncertain.

Several studies reported a substantial reduction in infection rates with NPWT. Stannard et al. demonstrated a significant reduction in deep infection following severe open fractures (8.4% vs. 20.6%; $p = 0.01$). Similarly, Blum et al. reported a significantly lower deep infection rate in open tibial fractures treated with NPWT (8.4% vs. 20.6%; $p = 0.01$), and multivariable analysis demonstrated NPWT to be independently protective against deep infection (odds ratio 0.38, 95% confidence interval 0.16–0.90). Similar findings were reported by Joethy et al., Virani et al., Sibin et al., and Kumaar et al., all of whom observed lower infection rates among patients managed with NPWT. Collectively, these studies suggest that NPWT may decrease bacterial contamination and reduce progression to deep infection during the interval between serial debridement and definitive soft-tissue coverage.

The biological rationale supporting NPWT is well established. Proposed mechanisms include removal of wound exudate, reduction of interstitial edema, improvement of local perfusion, stimulation of granulation tissue formation, and enhancement of angiogenesis. Experimental and clinical studies have demonstrated increased expression of angiogenic mediators and improved wound bed preparation with NPWT. Consistent with these mechanisms, several studies included in this review reported faster granulation tissue formation, greater wound size reduction, earlier readiness for definitive coverage, and shorter hospital stay among patients treated with NPWT.

Despite these encouraging findings, more recent evidence has challenged the assumption that NPWT consistently reduces infection. The WOLLF trial, a large multicentre randomized controlled trial involving patients with severe open lower-limb fractures, found no significant

differences between NPWT and standard dressings with respect to deep surgical site infection, wound healing, fracture union, functional outcomes, quality of life, or cost-effectiveness. Given its rigorous methodology, multicentre design, and large sample size, the findings of the WOLLF trial carry substantial weight and temper the conclusions drawn from earlier studies. Similarly, a large propensity-adjusted secondary analysis of the FLOW trial reported higher rates of deep infection among patients treated with NPWT. However, the authors acknowledged significant confounding by indication, as NPWT was more frequently used in patients with larger wounds, greater contamination, and more severe soft-tissue injury.

Several factors may explain the differences observed among studies. Many of the studies demonstrating benefit were single-centre investigations with relatively small sample sizes and were conducted in highly selected patient populations, predominantly Gustilo type III tibial fractures. Definitions of infection varied considerably between studies, and the timing of wound closure, debridement protocols, and NPWT application techniques were not standardized. Furthermore, several studies were retrospective in design and therefore susceptible to selection bias and unmeasured confounding. These factors limit direct comparison between studies and reduce confidence in pooled interpretation of the available evidence.

The available literature also has important limitations. Most studies focused on lower-extremity injuries, particularly open tibial fractures, which may limit generalizability to other anatomical regions. Considerable heterogeneity existed with respect to fracture severity, wound characteristics, outcome definitions, and duration of follow-up. Although several studies demonstrated favorable secondary outcomes with NPWT, these outcomes were inconsistently reported and frequently assessed using non-standardized measures.

From a clinical perspective, NPWT remains a useful adjunct in the management of complex open fracture wounds, particularly when delayed soft-tissue coverage is anticipated. The therapy appears to facilitate wound bed preparation and may improve several wound-related parameters. However, based on the current body of evidence, a consistent reduction in infection risk compared with conventional dressings has not been definitively established. Future high-quality randomized studies with standardized outcome measures are required to better define the role of NPWT in open fracture management.

Recommendation:

NPWT may be used as a bridge to definitive soft-tissue coverage in selected open fractures, particularly when repeated debridement or delayed closure is anticipated. Current evidence suggests that NPWT may improve local wound management; however, it has not consistently demonstrated a reduction in infection rates compared with standard dressings. NPWT should be considered an adjunct rather than a substitute for timely definitive soft-tissue coverage.

Strength of Evidence: MODERATE

Justification: The evidence base includes multiple comparative studies and randomized trials involving more than 2,500 patients. Most studies reported lower infection rates with NPWT; however, confidence in the overall estimate is reduced by heterogeneity, risk of bias in several studies, and conflicting findings from the largest multicentre randomized controlled trial. Therefore, the overall strength of evidence was considered moderate.