

HEALING UNDER NEGATIVE PRESSURE: CLINICAL OUTCOMES OF NEGATIVE PRESSURE WOUND THERAPY FROM DEBRIDEMENT TO DEFINITIVE CLOSURE

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ABSTRACT

Background: Complex wounds in patients with and without diabetes may require prolonged wound care and definitive closure. Negative pressure wound therapy (NPWT) is used to prepare wounds for closure, but outcomes may vary according to wound characteristics and patient factors. This study evaluated clinical outcomes of NPWT in diabetic and non-diabetic patients with complex wounds. **Materials and Methods:** This prospective observational comparative study was conducted in the Department of General Surgery, Government Virudhunagar Medical College Hospital. Thirty patients with complex wounds requiring NPWT were included, with 15 diabetic and 15 non-diabetic patients. All patients underwent surgical debridement followed by NPWT. Baseline characteristics, wound area, HbA1c, NPWT sittings, time to healthy granulation, hospital stay, and definitive wound management were assessed.

Result: The mean age was 59.87 ± 7.75 years in the diabetic group and 40.87 ± 10.89 years in the non-diabetic group. Mean wound area was 45.80 ± 14.48 vs 36.13 ± 9.83 cm² ($p=0.043$), and mean HbA1c was $7.90 \pm 0.92\%$ versus $5.25 \pm 0.17\%$ ($p<0.001$). Diabetic patients required more NPWT sittings (4.13 ± 0.74 vs 1.67 ± 0.62 ; $p<0.001$) and had longer hospital stays (5.80 ± 0.86 vs 3.20 ± 0.68 weeks; $p<0.001$). Healthy granulation developed after 3.4 versus 2.2 weeks. SSG was performed in 86.7% and 73.3%. **Conclusion:** NPWT was used as part of staged wound management in both groups. Differences in wound characteristics, age, and glycaemic control may have influenced treatment requirements. The observational design and absence of a non-NPWT control group limit causal interpretation.

INTRODUCTION

Diabetic foot ulcers are among the most serious complications of diabetes. About 19–34% of people with diabetes develop a foot ulcer during their lifetime, and these ulcers often precede a non-traumatic lower-limb amputation.^[1] Other wounds can also be slow and difficult to heal. These include wounds after wide local excision, below-knee amputation, cellulitis with tissue loss, and trauma. Such wounds often need repeated dressings, prolonged hospital stays, and a skin graft or another closure procedure. This adds to the physical, emotional and financial burden on patients and their families.

Negative pressure wound therapy (NPWT) was developed to help manage these wounds. It uses a foam or gauze dressing, an airtight seal and a suction pump to apply controlled negative pressure to the

wound. In early animal studies, suction at -125 mmHg increased granulation tissue formation.^[2] Later laboratory studies showed that this pressure gently stretches the wound surface and stimulates cell growth.^[3] NPWT also removes excess fluid and can reduce swelling. These effects help the wound bed become clean and healthy enough for grafting or closure.

Clinical studies in diabetic foot wounds have shown encouraging results. In a large randomized trial of 162 patients after partial diabetic foot amputation, NPWT led to faster wound closure and more granulation tissue than moist dressings.^[4] The 2023 IWGDF guidelines say NPWT may be considered for postoperative diabetic foot wounds.^[5] However, a Cochrane review found that the certainty of the evidence was limited.^[6] A later meta-analysis also examined the effectiveness and safety of NPWT in diabetic foot ulcers.^[7] Results in real-life practice

have been less consistent, and much depends on the type of wound, the patient's condition and the outcome measured.

Evidence outside diabetic foot ulcers is also mixed. In the WOLFF trial of 460 patients with severe open leg fractures, NPWT did not improve disability at 12 months compared with standard dressings.^[8] After major lower-limb amputation, a randomized trial of 50 patients found fewer surgical site infections with NPWT (12% vs 36%).^[9] NPWT is also commonly used to prepare the wound bed and to secure split-thickness skin grafts.^[10]

Most published studies look at one wound type in isolation. There is less information on how NPWT performs across the mixed wounds seen in routine surgical practice, and how diabetic and non-diabetic patients compare. This is particularly relevant in Indian hospitals, where patients often present late with large, infected wounds. Therefore the present study evaluated clinical outcomes of NPWT in patients with diabetic foot ulcers, wounds after wide local excision, wounds after below-knee amputation, cellulitis, and traumatic wounds.

Aim: To evaluate the clinical outcomes of NPWT in patients with diabetic foot ulcers, post wide local excision wounds, post belowknee amputation wounds, cellulitis and traumatic wounds.

MATERIALS AND METHODS

This prospective observational comparative study was conducted in the Department of General Surgery at Government Virudhunagar Medical College Hospital. Patients with diabetic wounds, post-below-knee amputation wounds, wounds following wide local excision, postoperative wounds, and traumatic wounds were included. All eligible patients underwent negative pressure wound therapy (NPWT) following complete surgical debridement. Patients were treated with antibiotics according to culture and sensitivity results. Only wounds without residual slough, pus discharge, or osteomyelitis after adequate surgical debridement were included in the study.

Study Population: Patients with complex wounds requiring NPWT were enrolled in the study. The study population included patients with diabetic ulcers, wounds following wide local excision, trauma, postoperative wounds, and post-below-knee amputation wounds.

Baseline clinical characteristics and wound-related parameters were recorded for all patients. These included HbA1c level and initial wound size.

Inclusion Criteria

Patients were included if they were willing to undergo NPWT; had wounds following wide local excision, trauma, postoperative procedures, below-knee amputation, or diabetic ulcers; had undergone complete surgical debridement without residual slough, pus discharge, or osteomyelitis; were planned

for split-thickness skin grafting or definitive wound closure; and were available for regular follow-up.

Exclusion Criteria

Patients were excluded if they were unwilling to undergo NPWT; had residual slough, persistent pus discharge, or osteomyelitis; had inadequate surgical debridement; had ongoing sepsis; or were unable to undergo definitive wound closure.

NPWT Management: All patients underwent NPWT after complete surgical debridement of the wound. NPWT was continued as clinically indicated until adequate wound-bed preparation was achieved for definitive wound closure or split-thickness skin grafting (SSG).

All patients received appropriate antibiotic therapy based on culture and sensitivity results. Wounds with residual slough, persistent pus discharge, or osteomyelitis were not included.

Clinical photographs were obtained at relevant stages of wound management, including following surgical debridement, during NPWT, and after adequate wound-bed preparation or definitive wound closure, where applicable.

Clinical Outcomes: The following clinical outcomes were assessed during the study:

- Time to development of healthy granulation tissue
- Number of NPWT sittings
- Duration of hospital stay
- Definitive wound management, including split-thickness skin grafting, secondary closure, or primary closure

HbA1c levels and initial wound size were also recorded to characterize patients and baseline wound status.

Statistical Analysis: Continuous variables were expressed as mean $\pm$ standard deviation (SD), while categorical variables were presented as frequencies and percentages. Continuous variables, including age, initial wound area, HbA1c, number of NPWT sittings, and duration of hospital stay, were compared between the diabetic and non-diabetic groups using the independent-samples t-test. Time to development of healthy granulation tissue was summarized descriptively. Categorical variables were presented as frequencies and percentages. A p-value <0.05 was considered statistically significant.

RESULTS

Thirty patients were included, with 15 patients in each group. The mean age was 59.87 ± 7.75 years in the diabetic group and 40.87 ± 10.89 years in non-diabetic group. The mean wound area was 45.80 ± 14.48 cm² and 36.13 ± 9.83 cm², respectively. Mean HbA1c was $7.90 \pm 0.92\%$ in the diabetic group and $5.25 \pm 0.17\%$ in the non-diabetic group. The mean number of NPWT sittings was 4.13 ± 0.74 and 1.67 ± 0.62 , while mean hospital stay was 5.80 ± 0.86 and 3.20 ± 0.68 weeks [Table 1].

Table 1: Baseline characteristics and outcomes

Parameter	Diabetic	Non-diabetic	p-value
Age, years (mean $\pm$ SD)	59.87 $\pm$ 7.75	40.87 $\pm$ 10.89	<0.001
Age range, years	45–70	17–56	—
Sex (M/F)	9/6	8 / 7	—
Initial wound area, cm ² (mean $\pm$ SD)	45.80 $\pm$ 14.48	36.13 $\pm$ 9.83	0.043
HbA1c, % (mean $\pm$ SD)	7.90 $\pm$ 0.92	5.25 $\pm$ 0.17	<0.001
NPWT sittings (mean $\pm$ SD)	4.13 $\pm$ 0.74	1.67 $\pm$ 0.62	<0.001
NPWT sittings, range	3–5	1–3	—
Hospital stay, weeks (mean $\pm$ SD)	5.80 $\pm$ 0.86	3.20 $\pm$ 0.68	<0.001
Hospital stay, range	5–7	2–4	—

The diabetic group included 8 diabetic foot wounds/ulcers/infections, 3 post-debridement wounds, 2 postoperative wounds, 1 post-amputation wound and 1 pressure sore. The non-diabetic group

included 8 traumatic wounds/ulcers, 3 postoperative wounds, 2 post-debridement wounds, 1 pressure sore and 1 wide local excision wound [Table 2].

Table 2: Wound etiology

Wound etiology	Diabetic (n=15)	Non-diabetic (n=15)
Diabetic foot wound/ulcer/infection	8	0
Post-debridement wound (including necrotising fasciitis)	3	2
Postoperative wound	2	3
Post-amputation wound (verruccous lesion with lymphoedema)	1	0
Pressure sore/bedsore	1	1
Traumatic wound/ulcer	0	8
Wide local excision (DFSP, abdominal wall)	0	1

SSG was performed in 13 diabetic patients (86.7%) and 11 non-diabetic patients (73.3%). Secondary closure was performed in 2 patients in each group

(13.3%), while primary closure was performed in 2 non-diabetic patients (13.3%) [Table 3].

Table 3. Final wound management

Final procedure	Diabetic (n=15)	Non-diabetic (n=15)
Split-thickness skin graft (SSG)	13 (86.7%)	11 (73.3%)
Secondary closure	2 (13.3%)	2 (13.3%)
Primary closure	0	2 (13.3%)
Time to healthy granulation	3.4 weeks	2.2 weeks

Diabetic Wound Post Wound Debridement And Post Npwt:



Figure 1: (A) Extensive lower-limb wound following surgical debridement. (B) Wound after NPWT, showing development of healthy granulation tissue.

The mean time to development of healthy granulation tissue was 3.4 weeks in the diabetic group and 2.2 weeks in the non-diabetic group. Patients received antibiotic therapy according to culture and sensitivity results, along with anti-inflammatory medications as clinically indicated.



Figure 2: (A) Stump following below-knee guillotine amputation. (B) Stump during subsequent wound management. (C) Stump after NPWT, showing development of granulation tissue.



Figure 3: (A) Non-diabetic wound with NPWT dressing in situ. (B) Wound following NPWT showing prominent granulation tissue and wound-bed preparation. (C) Further postoperative appearance of the wound showing a well-granulated wound bed.

Representative clinical photographs demonstrating wound appearance following debridement, during NPWT, and after wound-bed preparation or definitive wound management are shown in [Figure 1–7].



Figure 4: (A) Right foot wound following debridement and Ray's amputation of the third to fifth toes. (B) Wound following NPWT and subsequent split-skin grafting.

Non Diabetic Wound Pre And Post Npwt:



Figure 5: (A) Non-diabetic wound following surgical debridement and before initiation of NPWT. (B) Wound with NPWT dressing in situ. (C) Wound following NPWT showing a well-granulated wound bed with healthy granulation tissue.



Figure 6: Clinical appearance of a non-diabetic wound before and after negative pressure wound therapy. (A) Non-diabetic wound with NPWT dressing in situ. (B) Wound following NPWT showing development of a well-granulated wound bed.

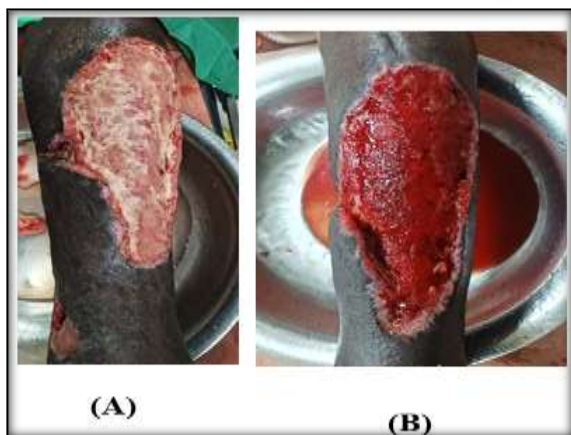


Figure 7: Clinical appearance of a wound before and after negative pressure wound therapy. (A) Wound following surgical debridement and before initiation of NPWT, showing an incompletely granulated wound bed. (B) Wound following NPWT, showing a predominantly healthy, well-granulated wound bed.

DISCUSSION

Complex lower-limb wounds can be difficult to manage because tissue loss, infection, diabetes, and delayed healing may prolong recovery and increase the need for repeated wound care. This study aimed to evaluate the clinical outcomes of negative pressure wound therapy (NPWT) in diabetic and non-diabetic patients with complex wounds. Overall, NPWT supported wound preparation and subsequent definitive closure in most patients.

In our study, diabetic patients were older and had larger wounds than non-diabetic patients, with higher HbA1c levels. Maranna et al. studied 45 patients with grade 1 and 2 diabetic foot ulcers, with 22 receiving NPWT and 23 receiving saline dressings.^[11] Seidel et al. in the DiaFu trial enrolled 368 adults with chronic diabetic foot ulcers across 40 centres.^[12] The older age, larger wounds and higher HbA1c observed in our diabetic group may partly explain the greater treatment burden in this group.

In the present study, diabetic patients required more NPWT sittings and had a longer hospital stay than non-diabetic patients. Similarly, Maranna et al. reported a shorter hospital stay with NPWT than with saline dressings (15.68 vs 29.00 days), while complete healing at 3 months occurred in 90.9% with NPWT versus 26.1% with saline dressings.^[11] Seidel et al. reported a shorter total treatment duration with NPWT than with standard moist wound care (82.8 ± 31.6 vs 98.8 ± 24.6 days; $p = 0.001$), along with a non-significant trend toward fewer dressing changes (35.1 ± 18.6 vs 42.9 ± 21.4 ; $p = 0.067$).^[13] These findings indicate that NPWT may reduce certain aspects of treatment burden compared with conventional wound care, although outcomes vary according to the wound population and endpoint assessed.

In the present study, healthy granulation developed after a mean of 3.4 weeks in diabetic patients and 2.2 weeks in non-diabetic patients. The longer duration in diabetic patients may reflect differences in wound size, etiology, and glycaemic control. However, this observed difference cannot be attributed to NPWT because of baseline group differences and the absence of a non-NPWT control group.

Within our study population, diabetic foot wounds and infections were the most common wound etiologies among diabetic patients, whereas traumatic wounds predominated in the non-diabetic group. Similarly, Qian et al pooled, randomized trials with 2,780 patients with open lower-limb fractures and reported a lower overall infection rate with NPWT (0.70, 95% CI 0.54–0.90).^[14] In the DiaFu per-protocol population, 6.8% of NPWT patients underwent surgical debridement compared with 26.4% of patients receiving standard moist wound care.^[13] These findings suggest potential benefits of NPWT in reducing infection-related outcomes in open lower-limb fractures and the need for surgical debridement in diabetic foot wounds, although these findings arise from different clinical populations.

In the present study, split-thickness skin grafting was the most frequently used definitive procedure in both groups, while secondary closure was less common. Similarly, Jiang et al. pooled. randomized trials with 488 patients. NPWT was associated with improved graft take, fewer days from grafting to discharge, and a lower risk of reoperation.^[15] In the DiaFu per-protocol population, defect coverage was required in 2 of 44 patients receiving NPWT and 2 of 110 receiving standard moist wound care; both NPWT cases involved skin grafting, whereas the standard-care group included one skin graft and one local flap.^[13] The high frequency of skin grafting in our series occurred following NPWT-based wound management; however, the present study was not designed to establish a causal relationship between NPWT and the subsequent need for grafting. However, evidence regarding definitive wound closure remains variable. In the DiaFu trial, among 345 participants in the modified intention-to-treat population, there was no significant difference in wound closure between NPWT and standard moist wound care.^[12] Niu et al. reported substantial heterogeneity for several outcomes, while hospital length-of-stay data were sparse and inconsistently reported, precluding reliable pooling.^[16]

CONCLUSION

In this prospective observational study, NPWT was used as part of staged wound management in diabetic and non-diabetic patients with complex wounds. Diabetic patients had larger wounds, required more NPWT sittings, and had longer hospital stays. Split-thickness skin grafting was the most common definitive procedure. These findings describe the clinical course of patients receiving NPWT and should be interpreted in view of the small sample size and differences between groups.

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