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A COMPARATIVE STUDY OF ULCER HEALING WITH NEGATIVE PRESSURE WOUND THERAPY VERSUS POVIDONE IODINE DRESSING

Surgery

Dr Kamal Rajput

Dr Shafak Thakral* *Corresponding Author

Dr Arpit Singhal

ABSTRACT

Introduction: Wound healing is a multifaceted physiological process, and chronic ulcers present considerable clinical challenges due to delayed repair and high risk of infection. Negative Pressure Wound Therapy (NPWT) is an advanced intervention that accelerates healing by applying controlled sub-atmospheric pressure, promoting granulation, and removing exudate. In contrast, Povidone Iodine (PI) dressing remains a widely used conventional approach. **Aim and Objectives:** This study aimed to compare the effectiveness of NPWT and PI dressing in chronic ulcer management. Specific objectives included evaluating wound size reduction, granulation tissue formation, time to healing, and length of hospital stay. **Materials and Methods:** A randomized prospective study was conducted on 80 patients aged 18–75 years with chronic ulcers. Participants were equally assigned to NPWT (Group A) or PI dressing (Group B). Wound characteristics, healing parameters, and hospitalization duration were recorded and analyzed using standardized protocols. Statistical comparisons employed t-tests and Chi-square tests. **Results:** NPWT demonstrated significantly better outcomes. Initiation of granulation occurred earlier in Group A (3.05 vs. 4.95 days, $p<0.001$) with faster completion (9.48 vs. 11.48 days, $p<0.001$). Mean wound area reduction was higher with NPWT (64.3% vs. 32.2%). Healing time and hospital stay were shorter in the NPWT group (12.72 vs. 14.5 days, $p<0.001$; 12.42 vs. 16.75 days, $p<0.001$). Post-treatment wound cultures were sterile in all NPWT patients compared to 45% in the PI group ($p<0.001$), and patients reported better pain control. **Conclusion:** NPWT is superior to conventional PI dressing in promoting faster ulcer healing, reducing infection rates, shortening hospitalization, and enhancing patient comfort and overall quality of life. Its use represents a significant advancement in chronic wound management.

KEYWORDS

Negative Pressure Wound Therapy, Povidone Iodine, Ulcer Healing, Granulation Tissue

INTRODUCTION

Wound healing is a complex physiological process that restores the integrity and function of damaged tissue through a coordinated sequence of hemostasis, inflammation, proliferation, and remodeling, each regulated by a variety of cells and biochemical mediators. Platelets initiate clot formation and release growth factors, attracting immune and repair cells, while neutrophils and macrophages clear debris and pathogens. Fibroblasts and endothelial cells promote tissue regeneration and angiogenesis. In normal conditions, these stages proceed efficiently; however, in chronic wounds, healing is disrupted, often arrested in the inflammatory phase due to underlying pathologies such as ischemia, infection, or systemic illnesses like diabetes mellitus, resulting in prolonged open wounds with a higher risk of complications [1].

The prevalence of chronic wounds is rising globally, largely due to the increasing burden of non-communicable diseases, including diabetes, vascular disorders, obesity, and age-related immobility. Chronic ulcers-particularly diabetic foot ulcers, venous leg ulcers, and pressure sores-pose significant clinical and public health challenges. Diabetic foot ulcers affect up to 25% of individuals with diabetes and account for most non-traumatic lower-limb amputations worldwide. Venous ulcers, often recurrent, develop in patients with chronic venous insufficiency, while pressure ulcers commonly affect bedridden and elderly individuals, rapidly progressing to extensive tissue damage if untreated [2]. These conditions exert profound impacts on healthcare systems, with chronic wounds affecting 1–2% of populations in developed nations and higher proportions in low- and middle-income countries. The financial burden is considerable due to prolonged hospitalization, recurrent outpatient care, surgical interventions, and long-term dressing requirements, often causing economic strain in resource-limited settings [3].

Beyond financial implications, chronic wounds impair quality of life through persistent pain, limited mobility, malodorous discharge, and frequent wound care, leading to social isolation and emotional distress. Complications such as secondary infections, osteomyelitis, sepsis, and amputations further increase morbidity and mortality, emphasizing the need for effective wound management strategies. Advanced therapies, including Negative Pressure Wound Therapy (NPWT), enhance perfusion and granulation formation and may offer advantages over traditional dressings like povidone-iodine. Comparative studies are essential to determine treatments that provide optimal outcomes while remaining cost-effective and accessible, particularly in low-resource settings [4,5].

Povidone-iodine has long been used in wound care due to its broad-spectrum antimicrobial activity and affordability, making it especially valuable in low-resource environments. While effective in reducing microbial colonization and preventing infection, its cytotoxic effects on fibroblasts and keratinocytes can impair granulation and epithelialization, delaying healing. Additionally, prolonged use may cause skin irritation, allergic reactions, or hinder accurate wound assessment due to its dark coloration [6,7].

NPWT, introduced in the 1990s, applies controlled sub-atmospheric pressure via a sealed dressing and suction device, promoting wound contraction, stimulating cellular proliferation, angiogenesis, and fibroblast activity, and facilitating robust granulation tissue formation. It removes exudate, reduces bacterial load, minimizes periwound edema, and maintains a moist wound environment conducive to healing. Clinical evidence demonstrates that NPWT accelerates wound size reduction, enhances granulation quality, shortens healing time, decreases hospital stay, and improves patient outcomes compared to conventional dressings [8,9].

Monitoring wound size reduction and granulation tissue formation provides an objective means to assess healing. Wounds treated with NPWT consistently show faster contraction and more vascularized granulation tissue than those managed with povidone-iodine, highlighting NPWT's superior efficacy in promoting tissue regeneration and achieving timely closure in chronic and complex wounds [10,11].

This study aims to compare ulcer healing outcomes between Negative Pressure Wound Therapy (NPWT) and Povidone Iodine Dressing. The primary objectives are to evaluate wound healing by assessing changes in wound size and the quality of granulation tissue, and to compare the duration of hospital stay required until the wound achieves full granulation. By analyzing these parameters, the study seeks to determine which treatment modality is more effective and efficient in promoting faster and better-quality wound healing.

MATERIAL AND METHODS

This prospective observational study was conducted at the Department of General Surgery, Kanti Devi Medical College Hospital & Research Centre, Mathura, UP, from September 2023 to January 2025. Ethical approval has been obtained from the Ethical Approval Committee of Kanti Devi Medical College Hospital & Research Centre, Mathura, UP.

Study Population

The study population comprised 80 patients aged 18–75 years with diabetic foot ulcers, pressure sores, traumatic wounds, or venous ulcers, while those with untreated osteomyelitis, malignant wounds, or wounds near joint cavities unsuitable for negative suction were excluded. Sample size was calculated based on previous prevalence studies using a power of 80% and 5% significance, resulting in approximately 73 ± 7 participants. Participants were randomly assigned to Group A (NPWT) or Group B (Povidone Iodine) using computer-generated block randomization and opaque sealed envelopes to ensure unbiased allocation.

Data Analysis

Data were collected prospectively using structured case report forms at baseline and predefined intervals, focusing on primary outcomes of time to initiation and completion of granulation, with secondary outcomes including wound size reduction, healing rate, microbiological clearance, hospital stay duration, pain scores, complications, total treatment duration, definitive closure at six months, and quality of life changes. Data were double-entered into a secure database and analyzed using IBM SPSS with descriptive statistics, t-tests, Mann-Whitney U, Chi-square, Fisher's exact tests, Kaplan-Meier curves, and log-rank tests, considering $p < 0.05$ as significant.

RESULTS

The study population consisted of 80 patients with a nearly balanced gender distribution of 51.25% males and 48.75% females, predominantly in the 41–50 (28.75%) and 51–60 (25%) age groups, indicating middle-aged adults are most affected by chronic and pressure-related ulcers, likely due to comorbidities and reduced healing capacity. Pressure sores (28.75%), chronic ulcers (25%), traumatic wounds (23.75%), and venous ulcers (21.25%) were the most common ulcer etiologies, with bedsore being the most frequent type (33.75%). Comorbidities included diabetes, hypertension, and anemia, while statistical analyses showed no significant differences in age, gender, ulcer type, or comorbidity distribution, ensuring a homogeneous cohort for evaluating treatment effects.

Table 1: Debridement method used for the treatment

Debridement Type	Number of Patients	Total %
Surgical	57	71.25
Enzymatic	23	28.75
Total	80	100
Chi (χ^2)- 14.45, **p-value**-<0.001		

Among 80 patients, 71.25% underwent surgical debridement and 28.75% enzymatic, with surgical methods significantly preferred ($\chi^2 = 14.45$, $p < 0.001$), reflecting its use for complex or necrotic wounds before advanced or conventional therapy.

Among the 80 patients with ulcers, clinical signs varied significantly, with most exhibiting mild pallor (52.5%), while moderate or absent pallor each accounted for 23.75%. Icterus was largely absent (91.25%), and pedal oedema was present in only 22.5%, indicating minimal hepatic or cardiac compromise. Other systemic signs, including clubbing (3.75%) and mild cyanosis (13.75%), were uncommon, with 82.5% showing none. Chi-square analysis confirmed highly significant differences ($p < 0.001$), indicating that most patients were systemically stable, allowing wound-healing outcomes to reflect treatment effects rather than underlying systemic illness.

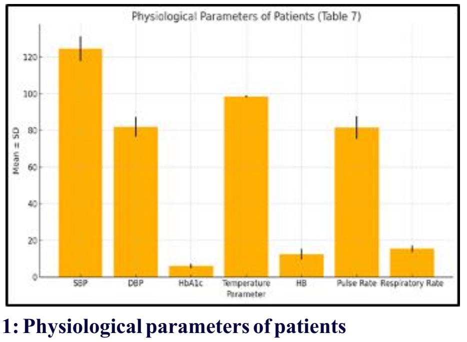

Figure 1: Physiological parameters of patients

Patients mostly had normal physiological parameters, with slightly elevated SBP (124.5 mmHg) and DBP (81.9 mmHg) and significantly higher HbA1c (6.06%, $p < 0.01$), while temperature, hemoglobin, pulse, and respiratory rate remained within normal limits, indicating overall hemodynamic stability.

Table 2: Biochemical parameters of patients

Parameter	Mean	SD	t-value	p-value
TLC	17255.16	2044.96	27.42	<0.001
Platelets	220132.6	39931.17	-5.30	<0.001
Bilirubin	0.84	0.19	-8.94	<0.001
SGOT	27.3	4.38	-4.14	<0.001
SGPT	31.85	4.1	-4.85	<0.001
Urea	22.94	4.64	-4.00	<0.001
Creatinine	1.02	0.16	1.00	0.32

Patients showed significantly elevated total leukocyte counts (17,255/mm³, $p < 0.001$) and slightly lower platelets, indicating mild inflammation, while liver and kidney function markers remained within normal limits, reflecting overall systemic stability before treatment.

Among the 80 patients, wound assessment revealed that 55% had multiple wounds, though this difference was not statistically significant ($p = 0.21$). Most wounds were of moderate depth (52.5%), with deep (27.5%) and superficial (20%) wounds also present, while purulent (27.5%) and serous (20%) exudates predominated. Surrounding skin was healthy in 38.75% but showed erythema or induration in others ($p < 0.001$). Pre-treatment cultures indicated predominance of Pseudomonas (32.5%) and E. coli (31.25%), and Doppler studies showed normal vascular flow in 62.5% with 37.5% having varicose veins or atherosclerotic changes, highlighting primarily local wound pathology with moderate infection and variable vascular compromise.

Table 3: Antibiotics used with the treatment

Antibiotic	Number of Patients	Total %
Meropenem	25	31.25
Ceftriaxone	20	25
Ciprofloxacin	12	15
Levofloxacin	12	15
Linezolid	10	12.5
Piperacillin-Tazobactam	1	1.25
Total	80	100
Chi (χ^2)- 26.02, **p-value**-<0.001		

Among 80 patients, Meropenem (31.25%) and Ceftriaxone (25%) were the most used antibiotics, with significant differences in prescription patterns ($\chi^2 = 26.02$, $p < 0.001$), reflecting targeted therapy against predominant Gram-negative infections.

Among the 80 patients, analgesic use was primarily Paracetamol (56.25%), followed by Diclofenac (37.5%) and Tramadol (6.25%), with no significant difference in distribution ($\chi^2 = 7.1$, $p = 0.069$), reflecting individualized pain management based on severity and tolerance. Treatment duration varied significantly ($\chi^2 = 15.59$, $p < 0.001$), with 56.25% of patients requiring 6–10 days and 43.75% needing over 10 days, indicating prolonged care for deep, infected, or slow-healing ulcers influenced by etiology, infection, and tissue response.

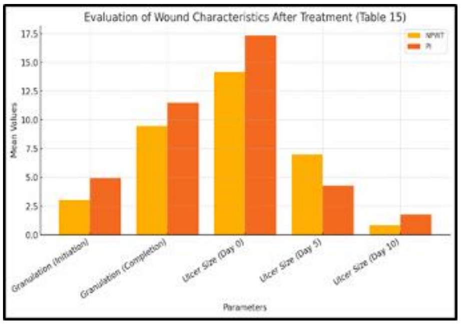

Figure 2: Evaluation of wound characteristics after treatment

After treatment, NPWT significantly accelerated wound healing compared to PI dressings, with earlier granulation initiation (3.05 vs. 4.95 days), faster completion (9.48 vs. 11.48 days), and greater ulcer size reduction by day 10 (0.85 vs. 1.76 cm²; all $p < 0.01$).

Analysis of wound healing outcomes among 80 patients revealed that Negative Pressure Wound Therapy (NPWT) was markedly superior to Povidone Iodine (PI) dressings. NPWT patients achieved greater reductions in wound size, with 77.5% showing over 40% decrease compared to 77.5% of PI patients showing only 21–40% reduction ($\chi^2 = 62.84$, $p < 0.001$). NPWT also significantly shortened healing time (12.72 vs. 14.5 days), accelerated healing rate, and reduced treatment duration (7.58 vs. 12.28 days), while both groups achieved similar infection clearance within 6–10 days. Mean wound area decreased from 15.75 ± 4.27 cm² to 5.63 ± 2.3 cm² with NPWT ($t = 17.52$, $p < 0.001$), and post-treatment cultures were negative in all NPWT patients versus 55% in the PI group ($\chi^2 = 40.00$, $p < 0.001$), demonstrating NPWT's superior efficacy in promoting granulation, wound contraction, and infection control.

Table 4: Duration of hospital stay after treatment

Hospital Stay	NPWT	PI	Total	Total %	Test-value	p-value
7-14 days	28	0	28	35	56.15	<0.001
15-21 days	12	40	52	65		
Mean hospital stays	12.42	16.75			10.25	<0.001
SD	1.74	1.77				

Patients treated with NPWT had significantly shorter hospital stays (12.42 vs. 16.75 days) compared to PI dressings, with most NPWT patients discharged within 7–14 days ($\chi^2 = 56.15$, $p < 0.001$), reflecting faster wound healing and recovery.

Baseline pain assessment of 80 patients using the Visual Analogue Scale (VAS) showed that 57.5% experienced severe pain (VAS 7–9) and 42.5% moderate pain (VAS 4–6), with no significant difference between the NPWT and Povidone Iodine (PI) groups ($\chi^2 = 1.20$, $p = 0.27$), ensuring comparable starting conditions. Post-treatment evaluation revealed a highly significant reduction in pain for NPWT patients ($\chi^2 = 38.42$, $p < 0.001$), with 32.5% reporting no pain and 67.5% mild pain, while most PI patients continued to experience moderate discomfort. These results indicate that NPWT provides superior pain relief, likely due to reduced dressing changes, a closed wound environment, and continuous exudate removal, enhancing both healing and patient comfort.

Table 5: Complications among patients after treatment

Complications	NPWT	PI	Total	Total %
Delayed healing	3	16	19	23.75
Infection	0	15	15	18.75
Minor infection	5	0	5	6.25
None	32	9	41	51.25
Total	40	40	80	100
Chi (χ^2)- 33.64, **p-value**- <0.001				

After treatment, NPWT patients experienced far fewer complications, with 80% having no or minor issues, compared to higher rates of delayed healing and infections in the PI group ($\chi^2 = 33.64$, $p < 0.001$), highlighting NPWT's superior safety and healing outcomes.

Table 6: Follow-up after 6 months of treatment

Follow Up after 6 months	NPWT	PI	Total	Total %
2 suturing	8	5	13	16.25
Planned ahead	7	11	18	22.5
SSG	25	24	49	61.25
Total	40	40	80	100
Chi (χ^2)- 1.05, **p-value**-0.59				

At 6-month follow-up, there was no significant difference between NPWT and PI groups in long-term interventions, with most patients (61.25%) undergoing split skin grafting, indicating comparable reconstructive outcomes despite NPWT's faster initial healing.

Table 7: Change in quality of life after treatment

Change in Quality of Life	NPWT	PI	Total	Total %
Negative	2	0	2	2.5
Positive	32	27	59	73.75
Undetermined	6	13	19	23.75
Total	40	40	80	100
Chi (χ^2)- 6.18, **p-value**-0.045				

Following treatment, NPWT patients reported greater quality-of-life improvement (80% vs. 67.5%, $\chi^2 = 6.18$, $p = 0.045$), reflecting faster healing, fewer complications, and enhanced physical and psychological well-being compared to PI dressing.

DISCUSSION

Chronic ulcers pose a substantial clinical challenge due to their prolonged healing, high infection risk, and significant impact on patient quality of life and healthcare resources. They commonly arise from conditions such as diabetes mellitus, peripheral vascular disease, pressure injuries, and trauma, often complicated by poor local perfusion, repeated contamination, and impaired tissue regeneration. Effective management is critical to promote timely healing, reduce complications, and minimize morbidity [12].

Conventional wound care, including povidone-iodine (PI) dressings, has been widely utilized for decades due to broad-spectrum antimicrobial activity, low cost, and ease of application [13]. While PI reduces microbial load and prevents infection, concerns exist regarding its cytotoxic effects on fibroblasts and keratinocytes, which may delay granulation tissue formation and epithelialization when used repeatedly. Consequently, chronic ulcers managed solely with antiseptic dressings often exhibit slow and inconsistent healing [8].

Negative Pressure Wound Therapy (NPWT) has emerged as an advanced modality that applies controlled sub-atmospheric pressure through a sealed dressing, promoting wound healing by reducing edema, improving local perfusion, enhancing granulation tissue formation, lowering bacterial burden, and facilitating exudate removal. Clinical studies consistently report faster wound contraction, improved tissue viability, and reduced dressing frequency with NPWT compared to conventional care [14]. Despite its effectiveness, NPWT's higher cost and requirement for specialized equipment necessitate careful comparison with conventional dressings, especially in resource-limited settings [15]. Evaluating healing outcomes, safety, and applicability between NPWT and PI provides evidence-based guidance for selecting optimal treatment strategies [15].

Our study of 80 patients demonstrated a heterogeneous ulcer profile, including pressure sores (28.75%), chronic ulcers (25%), traumatic ulcers (23.75%), venous ulcers (21.25%), and rare bite-related wounds, reflecting a broad clinical spectrum [95]. Comorbidities were common, with diabetes, hypertension, and anemia represented, while Doppler studies indicated that most ulcers were not primarily due to severe vascular insufficiency. Pre-treatment wound cultures showed a predominance of Gram-negative organisms, especially Pseudomonas (32.5%) and E. coli (31.25%). Surgical debridement was the primary method of wound preparation (71.25%), and broad-spectrum antibiotics were widely used, reflecting the inflammatory and infectious burden of chronic ulcers [16,17].

Post-treatment, NPWT demonstrated markedly superior outcomes compared with PI. Wound size reduction was significantly greater (mean reduction 41–80% vs. 0–40%), and granulation tissue formation and exudate control were enhanced [18]. NPWT also achieved 100% negative wound cultures versus 45% in the PI group ($p < 0.001$), reflecting superior infection control [19]. Patients receiving NPWT experienced faster healing (mean 12.72 vs. 14.50 days), shorter treatment duration, reduced pain scores (VAS 1.83 vs. 3.4), and fewer complications, including delayed healing or infection (7.5% vs. 77.5%, $p < 0.001$) [16]. Hospital stays were significantly shorter for NPWT-treated patients (12.42 vs. 16.75 days), indicating more efficient recovery [18,20].

Long-term outcomes, including reconstructive procedures such as split-thickness skin grafting, were comparable between NPWT and PI groups at six months, suggesting that NPWT primarily accelerates early healing and reduces complications, facilitating better preparation for closure [16]. Quality of life measures also favored NPWT, with 80% of patients reporting improvement compared with 67.5% in the PI group ($p = 0.045$), reflecting enhanced physical comfort, mobility, and overall well-being [21,22].

NPWT provides a superior therapeutic environment for chronic ulcers, promoting faster wound contraction, robust granulation, infection control, pain reduction, and shorter hospitalization compared with conventional povidone-iodine dressings. While both modalities ultimately allow for definitive closure, NPWT's mechanobiological advantages translate into earlier recovery, improved patient comfort, and enhanced quality of life, supporting its preferential use in appropriately resourced clinical settings [16,23].

CONCLUSION

This study demonstrated that Negative Pressure Wound Therapy (NPWT) is significantly superior to conventional Povidone Iodine dressing for managing acute and chronic ulcers, including pressure sores, venous ulcers, diabetic foot ulcers, and traumatic wounds. NPWT accelerates healing by promoting angiogenesis and granulation tissue formation, removing exudate and inflammatory mediators, reducing peri-wound edema, and approximating wound edges. Clinically, it shortens healing time, improves infection control, enhances patient comfort, reduces complications, shortens hospital stay, and improves quality of life. Overall, NPWT offers both clinical and economic advantages, supporting its use as a first-line therapy.

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