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ORIGINAL RESEARCH

Comparison of efficacy of negative pressure wound therapy versus conventional moist dressing in wounds healing by delayed primary intention and secondary intention

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ABSTRACT
Background: Chronic and non-healing wounds present a significant challenge in clinical practice. Negative Pressure Wound Therapy (NPWT) has gained recognition as an advanced method for promoting wound healing, especially in complex wounds. This study compares the efficacy of NPWT with conventional moist dressings in wound healing by delayed primary intention and secondary intention.**Methods:** A comparative interventional study was conducted on 60 patients with chronic non-healing wounds. Patients were randomly assigned to two groups: NPWT (Group A) and conventional dressing (Group B). Group A received NPWT with dressings changed every 72 hours, while Group B underwent conventional moist (normal saline) dressing changes every 24 hours. Wound healing was assessed using parameters such as time to wound closure, percentage of wound area healed, wound dimension reduction, and the number of dressings required.**Results:** The study revealed a statistically significant difference in the time taken for wound closure between the two groups. Patients in the NPWT group experienced faster wound healing, with a mean wound closure time significantly lower than that of the conventional dressing group ($p < 0.05$). Additionally, NPWT resulted in a greater percentage of wound area healed and fewer dressing changes compared to conventional methods. Diabetic foot ulcers were the most common wound type in both groups.**Conclusion:** NPWT demonstrated superior efficacy in promoting wound healing compared to conventional saline dressings. The therapy not only expedited wound closure but also reduced the need for frequent dressing changes, making it a cost-effective and efficient option for chronic wound management. Given its effectiveness, NPWT should be considered a viable treatment modality, particularly in cases of difficult-to-heal wounds.
Keywords: Negative Pressure Wound Therapy, conventional dressing, wound healing, chronic wounds, diabetic foot ulcer, wound closure.

INTRODUCTION

Negative Pressure Wound Therapy (NPWT) has revolutionized the field of wound management, especially for persistent and complex wounds that are resistant to conventional treatment. Initially designed for chronic and non-healing wounds, NPWT uses sub-atmospheric pressure, often termed as vacuum-assisted closure (VAC) or micro-deformational wound therapy (MDWT). Despite variations in terminology, NPWT remains the most widely accepted term in both clinical practice and research[1].

NPWT involves the application of a sealed airtight dressing over the wound, followed by the application of negative pressure via a vacuum device. This process creates a controlled environment that promotes wound healing through several mechanisms, including enhanced blood flow, reduction in tissue edema, and mechanical deformation of tissues that stimulates cellular activity[2]. The vacuum creates a negative pressure that induces micro-deformations at the wound surface, promoting angiogenesis and cell proliferation. Additionally, NPWT helps manage wound exudate and infection while maintaining a moist, thermally insulated wound environment, essential for optimal healing[3].

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The system consists of four main components: (1) a filler material or foam placed inside the wound, (2) a semi-permeable dressing to create a sealed environment, (3) a connecting tube to transport wound exudate, and (4) a vacuum device that provides negative pressure. The therapy works by contracting the foam and pulling the wound edges together, resulting in a reduction in wound size[4,5]. NPWT is typically applied after wound debridement and continues until wound closure, or as a preparation for surgical interventions such as skin grafts or flaps.

Over the past few decades, NPWT has proven highly effective across various wound types, including chronic wounds such as diabetic ulcers and pressure sores, as well as acute surgical and traumatic wounds. Numerous studies have validated its ability to expedite healing, reduce infection rates, and lower healthcare costs in treating difficult-to-manage wounds. The advantages of NPWT over conventional wound care include fewer dressing changes, better wound bed preparation, and reduced hospital stays, making it a valuable option in wound management[6].

Despite its success in Western countries, the adoption of NPWT in India has been slower due to high costs associated with imported NPWT devices. However, local innovations and the development of cost-effective alternatives have made NPWT more accessible in Indian healthcare settings. In recent years, the body of research on NPWT in India has grown, providing valuable insights into its application in Indian populations[7].

This study aims to evaluate the efficacy of NPWT compared to conventional dressing techniques in the management of difficult wounds. By analysing wound healing parameters such as time to wound closure, reduction in wound dimensions, percentage of wound area healed, and the number of dressings required, the study seeks to provide evidence-based recommendations for wound care practices.

AIM AND OBJECTIVES

AIM

To compare the efficacy of negative pressure wound therapy versus conventional moist dressing in wounds healing by delayed primary intention and secondary intention.

OBJECTIVES

To measure and compare the following in negative pressure wound therapy and conventional normal saline dressing:

- Time taken for wound closure.
- Serial reduction in wound dimensions and wound area.
- Percentage of wound area covered/healed.
- Number of dressings required till wound closure.

MATERIALS AND METHODS

Study Design

This study was a Comparative Interventional Study conducted to compare the efficacy of Negative Pressure Wound Therapy (NPWT) with Conventional Dressing in patients with chronic non-healing wounds. The study was carried out at a tertiary care hospital over a period of 12 months.

Sample Size

A total of 60 patients were enrolled, divided into two groups of 30 each:

- **Study Group (A):** 30 patients received NPWT, with dressings changed every 72 hours.
- **Control Group (B):** 30 patients received conventional moist (normal saline) dressing, changed every 24 hours.

The sample size was calculated assuming a 95% confidence interval, 80% power level, and based on mean time for wound healing as the primary variable, referring to a study by M.K. Dwivedi et al[8].

Sampling Technique

Simple random sampling was employed using a computer-generated randomization sequence.

Study Population

The study included a total of 60 patients who were diagnosed with chronic non-healing wounds and met the inclusion criteria. Patients were randomly allocated into two groups:

Inclusion Criteria

1. Patients aged 18 years and above.
2. Patients with chronic non-healing wounds of various etiologies of more than 4 weeks duration.
3. Patients who provided written informed consent.

Exclusion Criteria

1. Patients with malignancy-associated wounds.
2. Patients with active osteomyelitis.
3. Patients with untreated systemic infections.
4. Immunocompromised patients or those being treated with corticosteroids, immunosuppressive drugs or chemotherapy.
5. Patients with clotting disorders or on anticoagulant therapy.
6. Patients with conditions contraindicating the use of NPWT, such as active bleeding,exposed vital organs,dermatological conditions such as psoriasis, etc.

Randomization

Patients were randomized into two groups using a computer-generated random sequence. Random allocation was performed by an independent investigator not involved in the study procedures.

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Interventions

- **Group A (NPWT Group):** Patients received Negative Pressure Wound Therapy, where a sealed dressing was applied to the wound, and negative pressure was maintained using a vacuum-assisted device.
- **Group B (Conventional Dressing Group):** Patients in this group were treated with standard moist wound dressings, which were changed according to wound exudate levels and clinical judgment.

Data Collection

Data were collected for all patients at baseline and during follow-up visits at 1-week intervals for 6 weeks. The following parameters were recorded:

1. **Wound Area:** Measured using a standardized wound measurement tool at presentation and during each follow-up visit.
2. **Type of Wound:** Classified into categories such as diabetic foot ulcers, pressure sores, and others.
3. **Comorbidities:** The presence of comorbid conditions like diabetes, hypertension, and hypothyroidism was noted.
4. **Percentage of Wound Area Healed:** Calculated as the reduction in wound area over time.
5. **Time Taken for Wound Closure:** Defined as the number of days from the start of treatment to wound closure.
6. **Number of Dressings Applied:** The total number of dressings applied during the treatment period was recorded for each patient.

Outcome Measures

The primary outcomes were:

1. **Mean Wound Area:** The size of the wound at presentation and during follow-up was compared between the two groups.
2. **Percentage of Wound Area Healed:** The mean percentage of wound area healed was assessed at weekly intervals for both groups.
3. **Time to Wound Closure:** The mean time taken for wound closure was compared between the two groups.
4. **Number of Dressings Applied:** The total number of dressings applied in each group was documented and compared.

Statistical Analysis

Data were collected and entered in MS Excel. Statistical analysis was performed using SPSS version 28.0. Descriptive statistics (mean ± standard deviation) were used to summarize quantitative data. The chi-squared test and Fisher's exact test were applied for categorical variables. Independent t-tests and Mann-Whitney U tests were used to compare continuous variables. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment. All procedures were conducted in accordance with the Declaration of Helsinki.

Follow-up and Monitoring

Patients were followed up for a period of 6 weeks post-intervention. Regular wound assessments were conducted at each follow-up visit to monitor healing progress, and any complications were documented and managed accordingly.

RESULTS & ANALYSIS

Table 1: Distribution of Patients by Age Groups

Age Group (years)	Group A (NPWT)	Group B (Conventional Dressing)	Total Patients	Total Percentage (%)
18-20	1	0	1	1.67%
20-29	1	3	4	6.67%
30-39	2	1	3	5.00%
40-49	4	4	8	13.33%
50-59	7	6	13	21.67%
60-69	10	9	19	31.67%
70-79	4	3	7	11.67%
80-89	1	3	4	6.67%
90-99	0	1	1	1.67%
Total	**30**	**30**	**60**	**100%**
Mean Age (years)	55.87 ± 15.38	58.60 ± 18.03	-	p = 0.53

This table presents the age and gender distribution of the 60 patients in the study, divided equally into Group A (NPWT) and Group B (Conventional Dressing). It shows that the largest proportion of patients (31.67%) falls within the 60-69 years age group, followed by the 50-59 years group (21.67%). The smallest percentage (1.67%) of patients is in both the 18-20 and 90-99 age groups. The mean age of Group A was 55.87 years, while Group B had a mean age of 58.60 years, with no statistically significant difference between the two groups (p = 0.53).

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Table 2: Gender and Comorbidity Distribution Between Groups

Parameter	Group A (NPWT)	Group B (Conventional Dressing)	Total Patients	p-value
Gender				
Female	15 (50%)	11 (36.7%)	26 (43.3%)	0.301
Male	15 (50%)	19 (63.3%)	34 (56.7%)	
Comorbidities				
None	5 (16.67%)	7 (23.33%)	12 (20%)	1.000
Type 2 Diabetes Mellitus	20 (66.67%)	18 (60%)	38 (63.33%)	0.789
Hypertension	8 (26.67%)	9 (30%)	17 (28.33%)	1.000
Hypothyroidism	4 (13.33%)	2 (6.7%)	6 (10%)	0.671

This table compares the gender distribution and comorbidities between Group A and Group B. Both groups have a fairly balanced gender distribution, with Group A having an equal number of male and female patients, while Group B has more males (63.3%) than females (36.7%). In terms of comorbidities, Type 2 Diabetes Mellitus is the most common comorbidity, present in 66.67% of Group A and 60% of Group B. Other comorbidities, such as hypertension and hypothyroidism, were also analysed but showed no significant difference between the groups.

Table 3: Distribution of Wound Types in Study Population

Type of Wound	Group A (NPWT)	Group B (Conventional Dressing)	Total Patients	Total Percentage (%)
Non-healing wound with peripheral arterial insufficiency	1 (3.33%)	0	1	1.67%
Necrotizing soft tissue infection	3 (10%)	6 (20%)	9	15%
Diabetic foot	14 (46.67%)	12 (40%)	26	43.33%
Bedsore	1 (3.33%)	1 (3.33%)	2	3.33%
Infected large raw area wound	11 (36.67%)	9 (30%)	20	33.33%
Non-healing venous ulcer	0	2 (6.67%)	2	3.33%
Total	**30 (100%)**	**30 (100%)**	**60 (100%)**	**100%**

This table details the types of wounds present in both groups. Diabetic foot wounds were the most prevalent, accounting for 43.33% of the total patient population. Other wound types include infected large raw area wounds (33.33%) and necrotizing soft tissue infections (15%). Bedsore, non-healing venous ulcer, and wounds due to peripheral arterial insufficiency were less common, representing smaller percentages.

Table 4: Wound Healing and Closure Types

Parameter	Group A (NPWT)	Group B (Conventional Dressing)	p-value
Wound Area Healed (%)			
After 1 Week	31.86 ± 9.79	15.55 ± 5.21	<0.001*
After 2 Weeks	52.36 ± 12.88	29.65 ± 9.33	<0.001*
After 3 Weeks	57.88 ± 9.90	40.98 ± 10.94	<0.001*
After 4 Weeks	60.25 ± 0	48.55 ± 9.29	<0.001*
Type of Wound Closure			
Secondary Suturing	26 (86.67%)	28 (93.33%)	0.690
Split Thickness Skin Graft (STSG)	4 (13.33%)	2 (6.67%)	
Time Taken for Wound Closure (days)			
Secondary Suturing	13.37 ± 4.57	26.9 ± 7.54	<0.000*
STSG	11.00 ± 6.73	25.00 ± 5.66	0.05*
Total No. of Dressings Applied			
Secondary Suturing	4.77 ± 1.59	26.9 ± 7.54	<0.000*
STSG	4.00 ± 2.00	25.00 ± 5.66	0.008*

This table compares the wound healing outcomes and closure methods between the two groups. Group A demonstrated significantly higher percentages of wound area healed at each time point, with marked differences at 1, 2, 3, and 4 weeks ($p < 0.001$ for all comparisons). The type of wound closure was also evaluated, with most patients undergoing secondary suturing in both groups. The type of wound closure required was determined according to clinical judgement of the wound parameters and best modality

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allowing wound area skin cover was chosen (secondary suturing or skin grafts). Wound bed with complete healthy granulation coverage and nil exudate, with negative culture reportswere considered ready for wound closure and its day recorded. Group A required fewer days for wound closure (13.37 days for secondary suturing vs. 26.9 days for Group B) and fewer dressings applied, highlighting the efficacy of NPWT in faster healing and reduced need for intervention.

Table 5: Cost of Dressings in the Two Comparative Study Groups

Parameter	Group A: NPWT	Group B: Conventional Dressing
Cost per Dressing (per patient)	₹1400	₹200-250
Mean Number of Dressings Applied	4.77	26.9
Average Total Cost of Dressing (per patient)	₹6,678 (4.77x₹1400)	₹5,380 - ₹6,725 (26.9x₹200-250)
Cost Prohibitive Commercial NPWT Systems	₹5,000-10,000 (per dressing)	N/A
Patient Demographics	Mid/Low-Income	Mid/Low-Income

NPWT Group: The average total cost per patient was ₹6,678 based on the calculated cost of ₹1400 per dressing.
Conventional Dressing Group: With a higher number of dressings applied, the total cost ranged between ₹5,380 and ₹6,725 per patient. All other costs, including inpatient costs, medicines and investigations were similar for each group.

DISCUSSION

The present study provides a comprehensive comparative analysis of patients with chronic and difficult to heal wounds managed with Negative Pressure Wound Therapy (NPWT) versus conventional moist dressing, focusing on time taken for wound closure, the number of dressings required, and the overall wound healing rate. The findings are compared with existing literature, reinforcing the efficacy of NPWT in promoting faster and more efficient wound healing.

Age Distribution and Its Impact on Wound Healing

The study population had a mean age of 55.87 ± 15.38 years in the NPWT group and 58.60 ± 18.03 years in the conventional dressing group, with no significant difference in age distribution between the two groups. This observation is consistent with the study by ArunKumaar et al.[9], where older age was associated with delayed wound healing. Older individuals typically experience reduced skin elasticity, impaired immune responses, and a higher prevalence of comorbidities, all of which contribute to slower wound healing. Despite these factors, NPWT demonstrated superior results across all age groups, highlighting its effectiveness even in older populations.

Gender Distribution and Wound Healing Outcomes

The gender distribution showed a non-significant difference between the NPWT and conventional dressing groups, with a slightly higher number of male patients overall. While gender alone may not directly influence wound healing, its impact on comorbidities, wound etiology, and treatment responses should not be overlooked. Male patients in the study, particularly those with diabetic wounds, may have had higher rates of wound infections and complications, necessitating more aggressive wound management techniques such as NPWT[10].

Comorbidities and Their Role in Wound Healing

The prevalence of type 2 diabetes mellitus and hypertension was high in both study groups, particularly in the NPWT group (66.7%) compared to the conventional dressing group (60%). Diabetic wounds are notoriously difficult to heal due to microvascular complications, impaired immune function, and increased oxidative stress, which contribute to delayed healing and higher infection risks. The study by Tang et al[11]. supports this by noting how metabolic disorders in diabetic patients exacerbate oxidative stress and inflammation, leading to delayed wound resolution. NPWT's ability to promote granulation tissue formation and reduce infection risk makes it a highly effective treatment modality for diabetic foot patients.

Wound Type and Its Influence on Healing

Diabetic foot ulcers were the most frequently encountered wound type in both groups, with 46.67% in the NPWT group and 40% in the conventional dressing group. Studies by Vig et al.[12] and Armstrong et al.[13] have demonstrated that NPWT is particularly effective in managing diabetic foot ulcers, promoting faster wound closure and reducing the likelihood of complications. The present study corroborates these findings, showing that NPWT facilitates faster wound area reduction and healing even in complex wounds such as diabetic foot ulcers.

Wound Area Reduction and Healing Rate

The study demonstrated a significantly greater reduction in wound area and higher percentage of healed wound area in the NPWT group compared to the conventional dressing group. As early as the first week of intervention, the NPWT group exhibited a mean wound area reduction of 31.86% compared to 15.55% in the conventional dressing group, with this trend continuing throughout the study duration. These findings are consistent with those of Scherer et al.[14]

and Vig et al.[12], who found that NPWT accelerates wound healing by promoting angiogenesis, improving tissue perfusion, and modulating the inflammatory response. The present study's results reinforce the conclusion that NPWT is more effective than conventional dressings in reducing wound size and promoting faster healing.

Time Taken for Wound Closure

The time taken for wound closure was significantly shorter in the NPWT group, with an average of 13.37 ± 4.57 days for wounds closed by secondary suturing and 11 ± 6.73 days for wounds closed by split-thickness skin grafting (STSG). In comparison, the conventional dressing group required 26.9 ± 7.54 days for suturing and 25 ± 5.66 days for STSG. These results align with studies by Scherer et al.[14] and ArunKumaar et al.[9], who reported similar reductions in wound closure time with NPWT. The quicker development of a granulation tissue bed in the NPWT group enabled earlier interventions for final wound closure, such as suturing or grafting.

Number of Dressings Required

One of the most striking findings was the significant reduction in the number of dressings required in the NPWT group compared to the conventional dressing group. On average, only 4.77 ± 1.59 dressings were needed in the NPWT group for wounds closed by secondary suturing, compared to 26.9 ± 7.54 dressings in the conventional group. For wounds closed by STSG, the NPWT group required 4 ± 2 dressings compared to 25 ± 5.66 in the conventional group. This marked reduction in the number of dressings not only decreases the burden on healthcare resources but also improves patient comfort and reduces the risk of infection, as fewer dressing changes minimize the chance of contamination[15,16].

Cost-effectiveness

Although the cost of commercial NPWT devices is currently prohibitive due to the lack of widespread use, there is a potential for significant reduction in costs as its adoption increases and materials become available at wholesale rates. Despite the initial higher cost per dressing, the total expense incurred by the patient in both NPWT and conventional dressing groups is nearly equivalent.

However, NPWT offers significant advantages, including:

- **Reduced hospital stays:** Lowering overall healthcare costs for the patient.
- **Shorter treatment duration:** Accelerating return to normal activities and reducing indirect costs.
- **Improved outcomes:** Faster wound healing and reduced morbidity, leading to enhanced quality of life.

These factors highlight the cost-effectiveness and clinical benefits of NPWT, particularly in a hospital setting serving mid-to-low-income populations. While initial expenses may appear comparable, the long-term cost benefits make NPWT a compelling choice for wound management.

LIMITATIONS

This study had several limitations that should be considered when interpreting the results. The sample size was relatively small, with only 60 patients divided between the two groups, which may limit the generalizability of the findings. Additionally, the study was conducted in a single tertiary care centre, which may not fully capture variations in patient demographics and wound characteristics seen in broader settings. While efforts were made to account for comorbidities such as diabetes and hypertension, other confounding factors like nutritional status and wound care compliance were not extensively analysed. Furthermore, the duration of follow-up was limited to six weeks, preventing the assessment of long-term outcomes and recurrence rates.

CONCLUSION

This study supports the growing body of evidence that NPWT offers significant advantages over conventional moist dressing for chronic and difficult to heal wounds. NPWT demonstrated superior outcomes in terms of faster wound closure, greater reduction in wound area, fewer dressings required, and higher rates of granulation tissue formation.While NPWT has higher upfront costs, its clinical benefits and outcomes may outweigh these costs for specific cases, emphasizing the need for cost-effectiveness evaluation in resource-limited settings. These benefits were observed across all patient demographics, including those with comorbidities such as diabetes and hypertension. As a result, NPWT should be considered a valuable tool in the management of complex wounds, particularly in patients with delayed healing due to age, comorbidities, or wound type. Further studies with larger sample sizes and longer follow-up periods would help to validate these findings and optimize wound care protocols.

RECOMMENDATIONS

Future studies should aim to include larger, multi-centre cohorts to enhance the generalizability of the results. It would be beneficial to evaluate the comprehensive cost-effectiveness of NPWT, particularly in resource-limited settings, as well as to analyse the long-term outcomes such as wound recurrence and quality of life post-treatment. Additionally, incorporating a broader range of patient factors, such as nutritional status, wound etiology, and patient adherence to wound care protocols, could provide a more robust understanding of the factors influencing wound healing. Future research could also explore the role of NPWT in combination with other advanced wound care techniques, such as bioengineered tissues or growth factors, to optimize healing outcomes.

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