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RESEARCH ARTICLE

Evaluation of Wound Healing Outcomes with Conventional versus Negative Pressure Dressings in Surgical Patients

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Abstract: ***Background***: Optimal wound management is essential for improving recovery, minimizing infection, and reducing hospital stay. Conventional dressings, though widely used, often delay healing due to inadequate exudate control and bacterial contamination. Negative Pressure Wound Therapy (NPWT) has emerged as an advanced method that enhances wound healing by promoting granulation tissue formation, increasing perfusion, and reducing edema. This study aimed to evaluate and compare wound healing outcomes between conventional dressings and NPWT in surgical patients. ***Materials and Methods***: A prospective, randomized, comparative study was conducted among 60 surgical patients with wounds of varied etiology. Patients were randomly allocated into two groups: Group A received NPWT and Group B received conventional dressings. Wound area reduction, granulation tissue formation, infection rate, and duration of hospital stay were recorded and statistically analyzed. ***Results***: The NPWT group showed significantly greater mean wound area reduction and faster granulation tissue formation compared to the conventional dressing group ($p < 0.001$). Infection rates were lower in NPWT-treated wounds (10% vs. 30%), and mean hospital stay was shorter (12.1 ± 4.3days vs. 18.9 ± 5.4days). No serious complications related to NPWT were observed. ***Conclusion***: Negative Pressure Wound Therapy demonstrated superior wound healing outcomes, reduced infection rates, and shortened hospital stays compared to conventional dressings. Despite higher initial costs, NPWT proved to be more cost-effective overall due to improved healing efficiency and reduced resource utilization.

Keywords: Wound Healing, Outcome, Conventional, Negative Pressure Dressing, Surgical Patients

INTRODUCTION

Wound healing is a highly significant biological process involving hemostasis, inflammation, proliferation and remodelling phases, which collectively aim to restore tissue continuity and function. Optimal wound management in surgical patients is critical, since complications such as delayed healing, surgical-site infection (SSI) or wound dehiscence increase morbidity, prolong hospital stay and escalate cost and resource burden.[1-3] Conventional wound dressings—gauze, saline-moistened cotton pads or simple non-adherent dressings—have long been the standard of care. These dressings act as physical barriers, absorb exudate and aim to maintain a moist environment that supports granulation and epithelialisation. However, in many cases, especially with high-exudate, large or complex surgical wounds, conventional dressings may become saturated quickly, require frequent changes and may not adequately manage wound fluid, oedema or bacterial load, thereby limiting optimal healing.[4,5]

In response to these limitations, negative pressure wound therapy (NPWT)—sometimes referred to as vacuum-assisted closure (VAC)—has emerged as an advanced modality in wound management. First described by Argenta and Morykwas in the late 1990s, NPWT utilises a sealed wound dressing connected to a sub-atmospheric pressure source which continuously or intermittently removes wound exudate, reduces interstitial oedema, enhances perfusion and promotes granulation tissue formation through mechanical deformation of tissue and stimulation of cellular proliferation.[6,7] Mechanistically, NPWT has been shown to increase local blood flow, reduce bacterial bioburden, stimulate angiogenesis and accelerate wound contraction.[8-10]

Despite the accumulating evidence, some aspects remain unclear. While NPWT appears promising, cost, device-availability, training, and patient selection issues remain barriers especially in low- and middle-income countries (LMICs). Further, systematic reviews caution that the certainty of evidence about NPWT in closed surgical incisions is low to very low, and while SSI reduction is plausible, definitive high-quality randomized trials in diverse surgical populations are limited.[11,12] Moreover, the cost-effectiveness of NPWT (especially commercially available systems) remains contested: a recent UK-based economic evaluation found NPWT for surgical wounds healing by secondary intention was unlikely to be cost-effective from the healthcare payer's perspective.

The present study aims to compare wound healing outcomes between conventional dressing methods and NPWT in a surgical cohort. Key parameters to be evaluated include time to wound closure, rate of granulation tissue formation, incidence of surgical-site infection and wound dehiscence, frequency of dressing changes, duration of hospital stay and patient comfort/adherence.

Material and Methods

Study Settings

A **prospective, comparative observational study** was conducted in the Department of General Surgery of a Tertiary Care Teaching Hospital in North India over a period of 12 months from April 2021 March 2022. The hospital caters to a large number of postoperative and trauma patients, providing an appropriate setting for comparative evaluation of wound management techniques.

Study Population

All patients admitted to the surgical wards or postoperative units with wounds requiring regular dressing and meeting the inclusion criteria were considered for participation.

Inclusion & **Exclusion** Criteria

Patients aged **18 years and above** with postoperative wounds (infected or dehisced), traumatic wounds, or wounds left open for secondary healing with Wound size ≥ 4 cm² and willing to participate and comply with follow-up visits were included in the study. However patients with **malignant wounds** or **radiation-induced ulcers** or patients with **necrotizing fasciitis, osteomyelitis,** or **ischemic gangrene** and patients with **uncontrolled diabetes mellitus** (HbA1c > 9%) or **immune-compromised states** (HIV/AIDS, steroid therapy) were excluded from the study.

Sample Size Determination

Based on previous literature done in similar settings by Mohanraj M et. al (2018) [13] indicating a 25–30% improvement in wound healing rate with NPWT compared to conventional dressing and assuming 80% power with 5% level of significance, the minimum required sample size was calculated to be **60 patients (30 in each group).** Eligible patients were selected using **purposive sampling** and then **randomly allocated** into two groups using a computer-generated randomization table:

- **Group A (Conventional Dressing Group)** – treated with standard moist saline gauze dressing.
- **Group B (NPWT Group)** – treated with negative pressure wound therapy.

Intervention Protocols

➢ **Group A – Conventional Dressing**
- Wounds were cleaned with sterile normal saline or diluted povidone-iodine.
- Sterile gauze pads were applied and secured with adhesive tapes or roller bandages.
- Dressings were changed **once daily** or earlier if soaked or soiled.

➢ **Group B – Negative Pressure Wound Therapy (NPWT)**
- Wounds were cleaned and debrided of necrotic tissue if present.
- A sterile open-cell polyurethane foam sponge was cut to the size of the wound and placed directly on the wound bed.
- The area was covered with an occlusive transparent adhesive drape to create an airtight seal.
- The foam was connected via tubing to a vacuum device set at **125 mm Hg** of continuous or intermittent negative pressure.
- Dressings were changed every **48–72 hours** under sterile conditions or earlier if leakage occurred.

Assessment Parameters

Wound healing outcomes were evaluated using the following parameters:

1. **Wound Size Reduction (% area decrease)** – measured using graph paper tracing and planimetry on days 0, 7, 14, and 21.
2. **Granulation Tissue Formation** – assessed visually and graded as poor, fair, or good.
3. **Pain Score** – recorded using a **Visual Analog Scale (VAS)** at each dressing change.
4. **Exudate Amount and Odor** – graded semi-quantitatively (scant, moderate, copious).
5. **Time to Wound Bed Readiness for Closure** (secondary suturing/skin graft).
6. **Incidence of Wound Infection** – based on clinical findings and positive bacterial cultures.

Follow-up

Patients were followed until complete wound closure, discharge, or up to **28 days**, whichever occurred earlier. Outpatient follow-up was conducted at weekly intervals for two weeks post-discharge to monitor recurrence or delayed healing.

Outcome Measures

The **primary outcome** was the **rate of wound healing,** defined as percentage reduction in wound area and time to complete granulation. The **secondary outcomes** included infection rate, pain score, number of dressing changes, and duration of hospital stay.

Data Collection & **Statistical Analysis**

All observations were recorded in a **pre-structured case record form**. Wound measurements were taken by the same investigator to minimize inter-observer variation. Data obtained was compiled and analyzed using **SPSS software version 23.0** Continuous variables were expressed as **mean ± standard deviation (SD)** and compared using **Student's t-test**. A p-value < 0.05 was considered statistically significant.

Results

A total of **60 patients** with surgical wounds were included in the study and randomly allocated into two groups:

- **Group A (Conventional Dressing Group)** – 30 patients
- **Group B (Negative Pressure Wound Therapy Group)** – 30 patients

All participants completed the study and were followed until complete wound closure or up to 28 days.

Table 1. Demographic Characteristics

Parameter	Conventional Dressing (n=30)	NPWT (n=30)	p-value
Mean Age (years)	46.3 ± 12.5	45.7 ± 11.8	0.84
Gender (Male/Female)	20 / 10	19 / 11	0.78
Mean BMI (kg/m²)	23.6 ± 2.9	23.9 ± 3.1	0.67
Diabetes Mellitus (%)	7 (23.3%)	6 (20%)	0.74
Smoking History (%)	9 (30%)	8 (26.6%)	0.78

There was no statistically significant difference between the two groups in terms of baseline demographic variables, indicating proper comparability of groups.

Table 2. Type and Etiology of Wounds

Type of Wound	Conventional Dressing (n=30)	NPWT (n=30)
Postoperative infected wounds	14 (46.6%)	13 (43.3%)
Traumatic wounds	10 (33.3%)	11 (36.6%)
Pressure ulcers	4 (13.3%)	3 (10%)
Diabetic foot ulcers	2 (6.6%)	3 (10%)

Distribution of wound types was similar between both groups ($p > 0.05$).

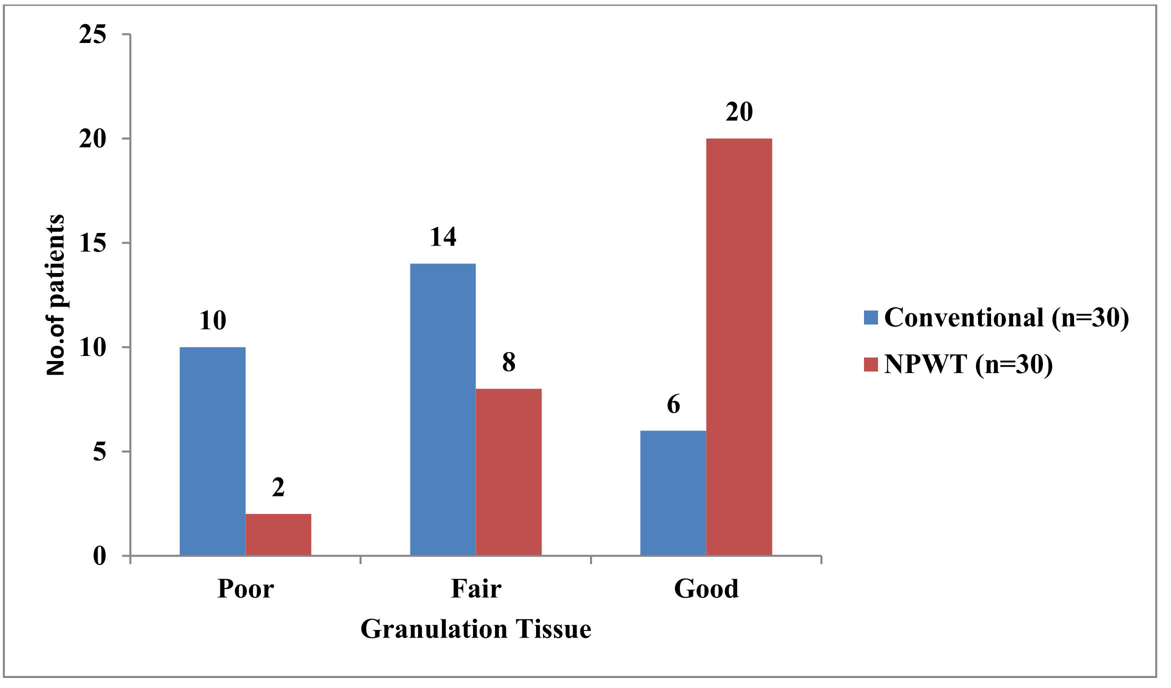
Table 3. Wound Size Reduction

Time Interval	Mean Wound Area (cm²) – Conventional	Mean Wound Area (cm²) – NPWT	% Reduction	p-value
Day 0	42.1 ± 10.2	43.7 ± 9.8	–	–
Day 7	35.4 ± 9.7	28.6 ± 8.9	15.9% vs 34.5%	*0.001**
Day 14	28.2 ± 8.8	19.1 ± 6.7	33.0% vs 56.3%	*<0.001**
Day 21	22.9 ± 7.6	12.6 ± 5.4	45.6% vs 71.2%	*<0.001**

**Significant at $p < 0.05$*

The mean wound area decreased significantly faster in the NPWT group compared to the conventional group at each follow-up interval, demonstrating improved healing progression.

Fig. 1 Granulation Tissue Formation



*Significant difference (Chi-square test, $p < 0.05$)
Good granulation tissue formation was significantly more frequent in patients treated with NPWT compared to those receiving conventional dressing.

Table 4. Pain Assessment (VAS Score)

Mean VAS Pain Score	Conventional Dressing	NPWT	p-value
Day 1	5.8 ± 1.2	5.6 ± 1.3	0.56
Day 7	4.7 ± 1.1	3.2 ± 1.0	*<0.001**
Day 14	3.9 ± 0.9	2.5 ± 0.8	*<0.001**

Pain scores decreased more rapidly in the NPWT group, indicating better patient comfort and reduced dressing-related discomfort.

Table 5. Wound Infection

Parameter	Conventional Dressing (n=30)	NPWT (n=30)	p-value
Wound infection (positive culture)	9 (30%)	3 (10%)	*0.04**

Infection rates were significantly lower in the NPWT group, suggesting better wound hygiene and bacterial control.

Table 6. Frequency of Dressing Changes and Hospital Stay

Parameter	Conventional Dressing (n=30)	NPWT (n=30)	p-value
Mean No. of Dressings	15.3 ± 3.2	8.7 ± 2.6	*<0.001**
Mean Hospital Stay (days)	18.9 ± 5.4	12.1 ± 4.3	*<0.001**
Mean Time to Wound Readiness for Closure (days)	20.6 ± 4.8	13.2 ± 3.9	*<0.001**

*Significant at $p < 0.05$

NPWT significantly reduced the number of dressing changes, hospital stay, and time to readiness for closure, highlighting superior clinical efficiency and cost-effectiveness in the long term.

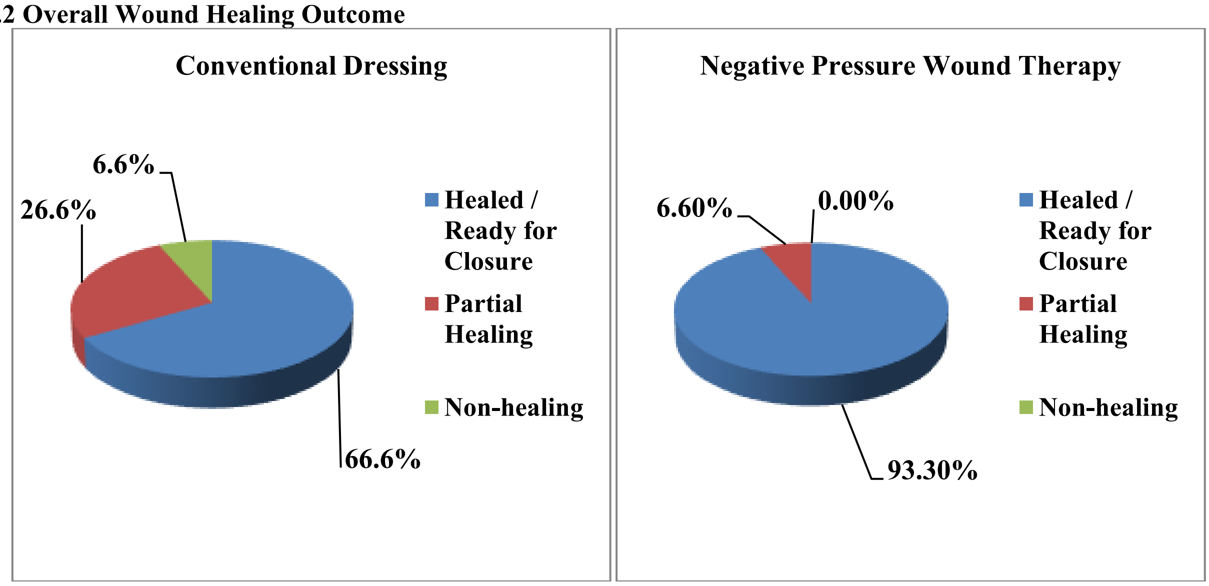
Table 7. Overall Wound Healing Outcome

Outcome Category	Conventional Dressing (n=30)	NPWT (n=30)	p-value
Healed / Ready for Closure	20 (66.6%)	28 (93.3%)	*0.01**
Partial Healing	8 (26.6%)	2 (6.6%)	
Non-healing	2 (6.6%)	0 (0%)	

**Significant at $p < 0.05$*

A significantly higher proportion of patients in the NPWT group achieved complete wound healing or readiness for closure by the end of the 21-day observation period.

Fig.2 Overall Wound Healing Outcome



Summary of Key Findings

- NPWT accelerated wound healing and granulation tissue formation significantly.
- It reduced infection rates, pain scores, number of dressings, and hospital stay.
- NPWT was associated with better patient comfort and fewer complications.
- Although the initial cost was higher, overall treatment efficiency and outcomes were superior to conventional dressing methods.

Discussion

The findings demonstrated that NPWT significantly improved wound healing parameters, including faster wound area reduction, enhanced granulation tissue formation, lower infection rates, and shorter hospital stays compared to conventional dressings.

The results of this study are consistent with several previous investigations worldwide that have established the clinical superiority of NPWT over traditional dressings. **Morykwas et al. (1997)** [7] first demonstrated that subatmospheric pressure enhanced local blood flow, promoted granulation tissue, and accelerated healing in animal models. Later, **Argenta and Morykwas (1997)** [6] successfully applied this principle in clinical practice, showing rapid wound closure and reduced bacterial colonization in human wounds.

In the present study, the mean wound area reduction was significantly greater in the NPWT group (71.2% by day 21) compared to the conventional group (45.6%), corroborating the results of **Malmsjö et al. (2009)** [14] who reported improved tissue perfusion and granulation with negative pressure application. Similarly, **Blume et al. (2008)** [15] in a multicentric randomized trial involving diabetic foot ulcers found higher healing rates and fewer amputations among patients treated with NPWT.

From the Indian perspective, our findings are supported by **Ravishankar et al. (2012)** [16] who observed significantly faster wound contraction and reduced infection rates in patients treated with NPWT for traumatic and post-surgical wounds. **Singh et al. (2019)** [17] also reported improved granulation tissue formation and decreased hospital stay duration in NPWT-treated wounds compared to conventional gauze dressings. In the present study, granulation tissue was "good" in 66.6% of NPWT-treated wounds versus only 20% in the conventional group, reinforcing these earlier observations.

Pain and patient comfort are crucial factors in postoperative wound care. In our study, patients under NPWT reported significantly lower mean pain scores after the first week compared to those under conventional dressing. This finding parallels the work of **Krug et al. (2011)** [18] who observed that the sealed moist environment created by NPWT minimizes dressing changes and associated discomfort. Furthermore, the reduced frequency of dressing changes (8.7 vs. 15.3) and shorter hospital stay (12.1 vs. 18.9 days) in our study echo the conclusions of **Costa et al. (2018)** [19] who reported that NPWT accelerates wound readiness for closure and allows early mobilization.

The infection rate in our study was significantly lower in the NPWT group (10%) than in the conventional group (30%). This aligns with the findings of **Orgill and Bayer (2013)**[20] who highlighted that negative pressure decreases bacterial load by continuous removal of exudate and prevents external contamination. **Vikatmaa et al. (2008)**[21] also confirmed reduced microbial colonization in NPWT-treated wounds, contributing to faster healing and fewer complications.

In addition, **Sharma et al. (2020)** [22] in an Indian tertiary care setting observed that NPWT reduced wound size and bacterial contamination significantly compared to conventional moist dressings, with notable cost savings due to decreased hospital stay. These findings support the cost-effectiveness observed in our study, where patients under NPWT required fewer interventions and achieved faster wound closure readiness. Mechanistically, the benefits of NPWT can be attributed to its multifactorial effects—macrodeformation that draws wound edges together, microdeformation at the cellular level stimulating angiogenesis, and removal of excess interstitial fluid that enhances oxygen and nutrient delivery.[23] These physiological effects translate into measurable clinical outcomes, as seen in our study.

Recommendations

1. **Adopt** Negative Pressure Wound Therapy as a routine adjunct for managing complex, infected, or slow-healing surgical wounds.
2. **Training programs** for surgical and nursing staff should be conducted to ensure proper NPWT device use and maintenance.
3. **Cost-benefit analyses** should be integrated into institutional policies to assess long-term savings from reduced hospital stays.

Limitations

1. The **sample size (n=60)** was relatively small, limiting generalization of results and **short follow-up period** prevented evaluation of long-term outcomes such as scar quality and recurrence.
2. The study did not include a detailed **cost-effectiveness analysis**, though indirect data suggested savings.
3. Variations in **surgeon technique and wound etiology** may have introduced subtle bias despite standardized care protocols.

Conclusion

The present study demonstrates that **Negative Pressure Wound Therapy** significantly accelerates wound healing compared to conventional dressing methods. Patients treated with NPWT showed faster wound contraction, enhanced granulation tissue formation, reduced infection rates, and shorter hospital stays. The therapy also improved patient comfort by minimizing pain and the frequency of dressing changes. Although the initial cost of NPWT is higher, overall treatment efficiency and reduced hospitalization make it more cost-effective in the long term.

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