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NEGATIVE PRESSURE WOUND THERAPY WITH SALINE INSTILLATION VERSUS CONVENTIONAL NEGATIVE PRESSURE WOUND THERAPY — A COMPARATIVE STUDY TO EVALUATE PATIENTS' OUTCOMES

Original Research

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ABSTRACT

Background: Wound management continues to be a critical challenge in surgical practice, with delayed healing often resulting in prolonged hospital stays, increased healthcare costs, and higher morbidity. Negative pressure wound therapy (NPWT) has been widely adopted to improve healing, and the addition of saline instillation (NPWTi) has emerged as a promising modification. However, comparative evidence assessing its effectiveness over conventional NPWT remains limited.

Objective: To compare wound outcomes between negative pressure wound therapy with saline instillation and conventional negative pressure wound therapy without instillation of normal saline.

Methods: A randomized controlled trial was conducted at the Department of General Surgery, Combined Military Hospital, from September 2022 to February 2023. Sixty-six patients meeting the inclusion criteria were enrolled and randomly assigned into two equal groups: Group A (NPWTi) and Group B (NPWT). Baseline characteristics including age, gender, and wound site were recorded. Patients were assessed for key wound outcome parameters: number of days until final surgical procedure, number of operative visits, percentage of wound closure, and percentage of wounds that remained closed at 30-day follow-up. Data were analyzed using SPSS version 22.0 with $p < 0.05$ considered statistically significant.

Results: The mean age of participants was 45.50 ± 6.53 years, with 37 (56.10%) males and 29 (43.90%) females. Foot was the most common wound site (60.60%). Mean days until final surgical procedure were significantly fewer in the NPWTi group (21.24 ± 1.67) compared to the NPWT group (25.33 ± 1.76; $p = 0.000$). Operative visits were also lower in NPWTi (4.06 ± 1.06 vs. 5.45 ± 1.12; $p = 0.000$). Differences in wound closure (87.88% vs. 78.79%; $p = 0.322$) and closure at 30 days (75.76% vs. 57.58%; $p = 0.117$) were not statistically significant.

Conclusion: Negative pressure wound therapy with saline instillation demonstrated superior outcomes in terms of reducing time to surgical closure and operative visits, supporting its use as an effective advancement over conventional NPWT.

Keywords: Negative-pressure wound therapy, NPWT, NPWTi, Saline instillation, Surgical wounds, Wound healing, Wound closure.

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INTRODUCTION

A wound, defined as a disruption to the continuity of human tissue, may involve the skin, mucous membranes, or deeper organ structures. These disruptions are often the result of trauma and require timely and appropriate management to prevent infection, mitigate complications, and ensure optimal healing (1). An essential aspect of wound care is classification, as it guides subsequent clinical decisions regarding disinfection, dressing, and therapeutic interventions (1,2). The Centers for Disease Control and Prevention (CDC) has established a widely accepted classification system, dividing wounds into four categories: clean (Class I), clean-contaminated (Class II), contaminated (Class III), and dirty (Class IV) (3). However, the clinical utility of this system has been challenged due to its subjective interpretation and poor inter-rater agreement among healthcare professionals. Furthermore, its application has shown limited success in neonatal surgical wounds, indicating a need for refinement or alternative approaches (4). Wound management presents persistent challenges in surgical practice. Healing is a complex biological process influenced by a cascade of cellular responses, extracellular matrix remodeling, and involvement of various growth factors (5). Impairment in this process can lead to delayed healing, which has significant implications for patient outcomes. Delayed wound healing is associated with increased mortality, prolonged hospital stays, extended time off work, and higher healthcare costs (6). Multiple risk factors contribute to impaired wound healing, including advanced age, elevated body mass index (BMI), prolonged operative duration, significant intraoperative blood loss, and the presence of chronic illnesses (7). These risk factors not only complicate the healing trajectory but also heighten susceptibility to wound infections, further worsening clinical outcomes (8).

To address these challenges, a range of therapeutic strategies—both conventional and advanced—have been employed to enhance wound healing. These include mechanical debridement, topical agents, skin grafts and flaps, application of skin substitutes, localized antibiotic therapies, and advanced dressings using hydrogel, hyaluronic acid, or alginate. Additionally, modalities such as infrared therapy, ultrasound-based therapy, platelet-rich plasma application, nanotechnology-based treatments, and negative pressure wound therapy (NPWT) have emerged as promising interventions (9). NPWT, in particular, has gained widespread use due to its ability to reduce wound dimensions, enhance granulation tissue formation, lower bacterial contamination, improve perfusion, and reduce edema (10). Despite its demonstrated efficacy, recent interest has focused on augmenting conventional NPWT with the instillation of normal saline—a technique referred to as NPWT with instillation (NPWTi). The rationale behind this approach lies in its potential to further optimize the wound environment by intermittently delivering fluid to cleanse the wound bed, thus removing bioburden and facilitating cellular regeneration. The combination of negative pressure with periodic saline instillation may accelerate healing and allow for earlier patient discharge, which is particularly crucial in the context of rising healthcare costs and hospital workload pressures (11). Given these considerations, this study aims to compare the wound outcomes of patients managed with negative pressure wound therapy with normal saline instillation versus those treated with conventional negative pressure wound therapy alone. The objective is to determine whether the addition of saline instillation confers measurable benefits in terms of wound healing efficacy, thereby guiding clinical practice toward more effective and resource-efficient wound management strategies.

METHODS

This prospective comparative study was conducted in the Department of Surgery at Combined Military Hospital, Rawalpindi, from September 2022 to February 2023, following approval from the Institutional Review Board (IRB) of the hospital. All participants provided written informed consent prior to enrolment, and the study was carried out in accordance with the ethical principles outlined in the Declaration of Helsinki. The sample size was calculated using the WHO sample size calculator, based on an assumed level of significance of 5%, power of 80%, and anticipated means of time to final surgical procedure. The expected mean duration for the group receiving negative pressure wound therapy with normal saline instillation (NPWTi) was 5.6 ± 3.6 days, while that for the group receiving conventional NPWT was 9.2 ± 5.2 days. This yielded a required total sample size of 66 participants, with 33 patients in each group, calculated using the standard formula for comparison of two independent means $\frac{2\sigma^2(z_{1-\alpha/2}+z_{1-\beta})^2}{}$ Participants were selected through non-probability consecutive sampling. The inclusion criteria were patients over the age of 18 years of either gender presenting with infected wounds. Patients were excluded if they had coagulation disorders, were immunocompromised, had diabetes mellitus, were on systemic corticosteroids for autoimmune or rheumatologic diseases, were undergoing chemotherapy for malignancy, or had wounds

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with exposed bone or tendon (2,3). After enrollment, baseline demographic and clinical details including age, gender, and anatomical site of the wound (arm, thigh, leg, foot, or buttocks) were documented.

To ensure methodological rigor, patients were randomly assigned into two groups using a computer-generated random sequence rather than a manual lottery method. Allocation was concealed using sealed opaque envelopes to minimize selection bias. Group A (NPWTi) consisted of 33 patients who received negative pressure wound therapy with 0.9% normal saline instillation, and Group B (NPWT) comprised 33 patients managed with conventional negative pressure wound therapy without saline. In both groups, therapy was administered using a standard negative pressure of 125 mmHg. In the NPWTi group, normal saline instillation was applied with a dwell time of 20 minutes before suction (3). Primary outcome measures included the number of days to final surgical procedure. Secondary outcomes were the number of operative visits, percentage of wound closure (defined as coverage by delayed primary closure, flap, or graft), and percentage of wounds that remained closed at 30 days post-treatment. To minimize assessment bias, outcome evaluators were blinded to the treatment group assignments. Data were analyzed using SPSS version 22.0. The normality of continuous variables was assessed using the Shapiro-Wilk test (5). Quantitative variables were expressed as means with standard deviations or medians with interquartile ranges (IQRs), and qualitative variables were presented as frequencies and percentages. Comparisons between groups were conducted using the unpaired t-test for quantitative data and the chi-square test for categorical variables. A p-value < 0.05 was considered statistically significant.

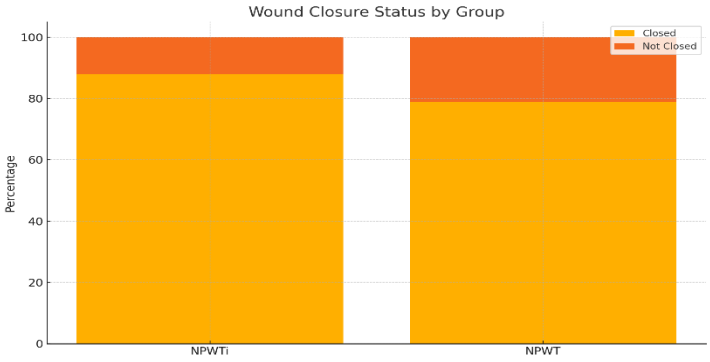
RESULTS

A total of 66 patients were enrolled in the study, with 33 patients assigned to each group: the negative pressure wound therapy with saline instillation (NPWTi) group and the conventional negative pressure wound therapy without instillation (NPWT) group. The overall mean age of the participants was 45.50 ± 6.53 years. Among the study population, 56.1% (n=37) were male and 43.9% (n=29) were female. The most frequently involved anatomical site was the foot (60.6%, n=40), followed by the thigh (19.7%, n=13), arm (12.1%, n=8), and buttocks (7.6%, n=5). On comparing baseline characteristics between the two groups, the mean age in the NPWTi group was 43.45 ± 5.76 years, significantly lower than that in the NPWT group, which was 47.54 ± 6.69 years ($p = 0.010$). Gender distribution between the two groups did not differ significantly ($p = 0.804$), with the NPWTi group consisting of 54.55% males and 45.45% females, and the NPWT group comprising 57.58% males and 42.42% females. Wound site distribution was also similar between both groups with no statistically significant difference ($p = 0.855$). In each group, 60.61% of patients had foot wounds, followed by thigh, arm, and buttocks in similar proportions. In terms of clinical outcomes, the NPWTi group demonstrated significantly earlier readiness for definitive surgical intervention. The mean number of days until the final surgical procedure was 21.24 ± 1.67 days in the NPWTi group, compared to 25.33 ± 1.76 days in the NPWT group ($p = 0.000$). Similarly, the NPWTi group had a significantly lower number of operative visits (4.06 ± 1.06) versus the NPWT group (5.45 ± 1.12) with a p-value of 0.000.

Regarding wound closure, 87.88% (n=29) of patients in the NPWTi group achieved complete wound closure compared to 78.79% (n=26) in the NPWT group; however, this difference was not statistically significant ($p = 0.322$). At 30-day follow-up, wound closure was sustained in 75.76% (n=25) of NPWTi patients, while 57.58% (n=19) of NPWT patients maintained wound closure, again showing a non-significant difference ($p = 0.117$). To further enhance the robustness of the analysis, confidence intervals were calculated for key continuous outcomes. For the mean number of operative visits, the NPWTi group showed a 95% confidence interval ranging from 3.68 to 4.44, while the NPWT group had a confidence interval of 5.05 to 5.85, indicating a clear separation and supporting the statistical significance of this outcome.

Table 1 Baseline characteristics

Sr. No.	Characteristics		Value
1	Mean age		45.50 - 6.53years
2	Gender	Male	37 (56.10%)
		Female	29 (43.90%)
3	**Site of wound** **Foot Thigh Arm Buttocks**		**40 (60.60%** **13 (19.70%)** **8 (12.10%)** **5 (7.6%)**



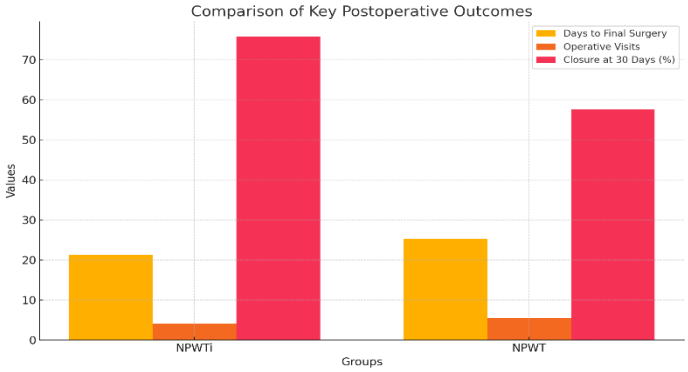


Table 2 Comparison of Baseline Characteristics between Groups

Characteristic	NPWTi group		NPWT group		p-value
Age	43.45 * 5.76 years		47.54 * 6.69 years		0.010
Gender	Male	Female	Male	Female	0.804
	18 (54.55%)	15 (45.45%)	19 (57.58)	14 (42.42%)	
Site of wound	Foot	20 (60.6%)	Foot	20 (60.6%)	0.855
	Thigh	6 (18.18%)	Thigh	7 (2 1.2 1%)	
	Arm	5 (15.15%)	Arm	3 (9.09%)	
	Buttocks	**2 (6.06%)**	**Buttocks**	**3 (9.09%)**	

Table 3 Comparison of post-operative parameters

Parameter	NPWTi group		NPWT group		p-value
Mean number of days till final surgical procedure	21.24 - 1.67		25.33 - 1.76		0.000
Mean number of operative visits	4.06 - 1.06		5.45 - 1.12		0.000
Wound closure	Yes	No	Yes	No	0.322
	29 (87.88%)		26 (78.79%)		
Wound closure at 30 days	Yes	No	Yes	No	0.117
	25 (75.76%)	**8 (24.24%)**	**19 (57.58%)**	**14 (42.42%)**	

Table 4 Confidence Intervals for Operative Visits

Outcome	Group	Mean	95% CI Lower	95% CI Upper
Days to Final Surgery	NPWTi	4.06	3.68414	4.43586
Operative Visits	NPWT	5.45	5.052865	5.847135

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Table 5 Confidence Intervals for Key Outcomes

Outcome	Group	Mean	95% CI Lower	95% CI Upper
Days to Final Surgery	NPWTi	21.24	20.64784	21.83216
Operative Visits	NPWT	25.33	24.70593	25.95407

DISCUSSION

The present study was conducted with the aim of evaluating and comparing the wound healing outcomes associated with negative pressure wound therapy with saline instillation (NPWTi) versus conventional negative pressure wound therapy without instillation (NPWT). The analysis revealed that the majority of the patients in both groups presented with foot wounds, followed by wounds on the thigh, arm, and buttocks. This distribution is reflective of the pattern commonly observed in similar surgical populations, as documented in earlier studies where foot wounds were noted as the most prevalent anatomical site (12). In comparing the baseline characteristics between the two groups, it was observed that the distribution of gender and wound site was statistically comparable (11,12). However, the age difference between groups reached statistical significance, with patients in the NPWT group being older on average. While this age disparity could potentially confound outcome measures such as healing time, the application of randomization and outcome blinding helped reduce bias in treatment effect estimation (13,14). Nonetheless, the significant age difference should be considered when interpreting the results. Regarding wound outcomes, the study demonstrated statistically significant reductions in both the mean number of days until the final surgical procedure and the mean number of operative visits in the NPWTi group (15). These findings are aligned with previous research that also reported more favorable timelines and fewer surgical interventions in patients managed with saline instillation during negative pressure therapy (16,17). These outcomes suggest that NPWTi may offer a more efficient healing trajectory. Although the frequency of wound closure and sustained closure at 30 days was higher in the NPWTi group, these differences did not reach statistical significance in this study (18,19). This is consistent with earlier findings where trends favored NPWTi but failed to demonstrate significance due to variability in patient populations or sample size limitations (20).

One of the notable strengths of this study is the inclusion of outcome assessor blinding and the use of computer-generated randomization, both of which enhance the internal validity of the findings. The study also benefitted from clearly defined inclusion and exclusion criteria, a consistent intervention protocol, and standardized outcome measurements. However, several limitations should be acknowledged. The sample size, although statistically powered, may not have been large enough to detect significant differences in all secondary outcomes such as long-term wound closure. Additionally, the lack of subgroup analysis by wound site, depth, and comorbid conditions may have obscured outcome variations among clinically distinct subpopulations. The statistically significant difference in mean age between the groups is another potential confounder that was not adjusted for using multivariate analysis. Moreover, while short-term follow-up was conducted to assess closure at 30 days, longer-term healing sustainability and functional outcomes were not evaluated. The study was also conducted at a single center, limiting the generalizability of the findings. The clinical implications of this study suggest that NPWTi can reduce surgical burden and accelerate wound readiness for definitive closure. These findings provide a rationale for incorporating saline instillation into standard negative pressure wound protocols, especially in high-risk or resource-constrained surgical environments. However, the lack of significant differences in closure rates and the need for further validation across broader clinical settings underscore the importance of continued research. Future studies should aim to include larger, multicenter samples, perform stratified analyses across wound types and patient demographics, and evaluate long-term outcomes to guide clinical decision-making regarding the integration of instillation-based therapies into routine surgical practice.

CONCLUSION

In conclusion, this study demonstrated that negative pressure wound therapy with saline instillation offers more favorable wound outcomes compared to conventional negative pressure therapy without saline. The addition of saline instillation contributed to faster readiness for surgical closure and reduced operative interventions, suggesting a more efficient healing process. These findings reinforce the clinical value of incorporating saline instillation into wound care protocols and highlight its potential to enhance recovery while reducing the overall treatment burden. This approach may serve as a valuable strategy in optimizing wound management, particularly in settings where timely healing is critical for improving patient outcomes.

Author Contribution

Author	Contribution
Umer Mushtaq*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Shoaib Khan	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Kishmala	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Muhammad Saqlain	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sana Zahra	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sher Afgan Raisani	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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