Original Research

A MODIFICATION OF VACUUM-ASSISTED WOUND CLOSURE VERSUS CONVENTIONAL DRESSING: A COMPARATIVE STUDY

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ABSTRACT

Background- Management of complex and chronic wounds remains a major surgical challenge, particularly in resource-limited settings. Although VAC (Vacuum-Assisted Closure) therapy has demonstrated superior wound healing outcomes compared to conventional dressings, the high cost of commercial systems limits widespread use. This study evaluates the efficacy of an innovative, indigenously modified vacuum-assisted wound closure technique using locally available materials compared to conventional dressing in wound management. **Methods-** A prospective case-control study was conducted in the Department of General Surgery at Karnataka Institute of Medical Sciences (KIMS), Hubballi, over 24 months. A total of 80 patients aged 18–70 years were enrolled and divided into two equal groups: The control group (n=40) received conventional dressings, and the experimental group (n=40) received modified VAC therapy using autoclaved sponge, suction catheter, and locally available vacuum devices (portable suction, syringe, or Romovac). Parameters assessed included wound area, wound score, number of debridements, frequency of dressing changes, hospital stay, pain score (VAS), microbiological culture, complications, and mode of healing. Statistical analysis was performed using appropriate tests, with $p<0.05$ considered significant. **Results-** Both groups were comparable at baseline ($p>0.05$). The experimental group showed significantly greater reduction in wound area (111.23 ± 64.29 cm² vs. 141.18 ± 19.43 cm²; $p=0.006$) and lower final wound score (6.55 ± 2.30 vs. 8.60 ± 2.06; $p<0.001$). The number of debridements (1.35 ± 1.39 vs. 2.85 ± 1.41; $p<0.001$), frequency of dressing changes (10.23 ± 4.57 vs. 26.85 ± 10.27; $p<0.001$), and hospital stay (31.83 ± 11.98 days vs. 38.55 ± 14.30 days; $p=0.025$) were significantly lower in the experimental group. Pain scores were comparable ($p=0.451$). By the third culture, "No Growth" was observed in 60% of experimental patients compared to 40% in controls. Complications were minimal. **Conclusion-** The indigenously modified vacuum-assisted wound closure technique is significantly superior to conventional dressing in promoting wound healing, reducing dressing frequency, minimizing debridements, and shortening hospital stay. It is a safe, effective, and cost-efficient alternative suitable for resource-constrained settings.

Keywords: Modified VAC, Negative Pressure Wound Therapy, Conventional Dressing, Wound Healing, Chronic Ulcer, Cost-Effective Wound Care.

www.ajmrhs.com
eISSN: 2583-7761
Date of Received: 10-01-2026
Date Acceptance: 25-02-2026
Date of Publication: 07-03-2026

doi.org/10.65605/a-jmrhs.2026.v04.i01.pp510-516

INTRODUCTION

Wound management remains one of the most fundamental challenges in surgical practice. Chronic and complex wounds impose a significant global healthcare burden, affecting millions annually and generating substantial economic costs. In India, the prevalence of chronic wounds is estimated at 4.5 per 1000 population, with diabetic foot ulcers, pressure

ulcers, and traumatic wounds constituting the majority of cases requiring advanced care. Beyond the immediate clinical challenge, these wounds adversely impact patient quality of life, functional outcomes, and healthcare resource utilization.

Conventional wound management methods, including wet-to-dry dressings and saline-soaked gauze, have long served as the cornerstone of treatment. However, these approaches often require frequent dressing changes, cause patient discomfort, and show variable effectiveness in promoting rapid wound healing.[1] These limitations have led to the development of advanced wound care technologies, among which NPWT (Negative Pressure Wound Therapy) has emerged as a revolutionary modality.

VAC (Vacuum-Assisted Closure), introduced in the 1990s, applies controlled sub-atmospheric pressure to the wound bed through a foam dressing connected to a suction device.[2] This technique enhances granulation tissue formation, reduces bacterial colonization, removes excess exudate, and improves local perfusion, thereby accelerating healing in diabetic ulcers, pressure sores, traumatic wounds, and post-surgical dehiscence.[3] The mechanism involves wound edge approximation, reduction of interstitial edema, stimulation of angiogenesis, and mechanical microdeformation that promotes cellular proliferation and extracellular matrix deposition.[4] Studies report that NPWT can reduce wound volume by 50–60% within the first week of treatment compared to conventional dressings.[5]

Despite proven efficacy, commercial VAC systems are expensive and often inaccessible in resource-constrained settings, particularly in developing countries. Efforts to develop cost-effective, indigenized modifications using locally available materials have shown promising results.[6] However, robust comparative evidence evaluating these modified systems against conventional dressings remains limited.[7] Therefore, there is a clear need for well-designed studies assessing the clinical effectiveness, safety, and cost-efficiency of modified VAC systems to inform evidence-based wound management practices in resource-limited environments.[8]

Aim and Objectives

The study aims to compare the efficacy of an innovative modification of vacuum-assisted wound closure with conventional dressing in wound management. The objectives were to evaluate and compare the rate of wound healing between the two groups, assess the frequency of dressing changes required during treatment, determine the effectiveness of the modified technique in preparing a faster and healthier granulation bed suitable for subsequent surgical interventions, measure the rate of wound edge contraction, analyze its role in minimizing wound contamination, and examine its impact on reducing the duration of hospital stay.

MATERIALS AND METHODS

Study Design- This study was conducted as a case-control study in the Department of General Surgery at Karnataka Institute of Medical Sciences (KIMS), Hubli, over a period of 24 months from March 2024 to December 2025. The study was systematically planned and executed in phases. The initial phase (March–April 2024), accounting for 5–10% of the study duration, involved understanding the research problem and preparation of the study proforma/questionnaire. The major phase of the study (May 2024–May 2025), constituting up to 80% of the study period, included a pilot study, validation of the questionnaire, patient enrolment, data collection, and data manipulation. This was followed by the analysis and interpretation phase (June–August 2025), accounting for 5–10% of the study time. The final phase (September–December 2025), also comprising 5–10% of the study duration, involved dissertation writing, compilation of results, and submission.

Inclusion and Exclusion Criteria- Patients included in the study were those presenting with chronic pressure ulcers, diabetic ulcers, neuropathic ulcers, wounds with exposed bone and tendons, and partial-thickness burns. Patients were excluded if they had wounds involving a very large surface area (more than 30% of body surface area or involving regions such as the groin, perineum, or axilla), malignancy within the wound, cavities or sinuses of unknown depth or origin, untreated osteomyelitis in the vicinity of the wound, wounds associated with unstable fractures or loose bone fragments, ulcers over extremities with peripheral vascular disease, wounds with exposed major blood vessels or organs, or acute burns.

Sample Size Calculation- The study population comprised all patients aged between 18 and 70 years from the Department of General Surgery at Karnataka Institute of Medical Sciences who satisfied the inclusion criteria. The study included both admitted cases and OPD (Out-Patient Department) cases.

The total sample size was 80 patients, divided into two groups:

- Case group (Vacuum-assisted closure): 40 patients
- Control group (Conventional dressing): 40 patients.

The minimum sample size was calculated based on an estimated prevalence of p = 29.72% and q = 70.28% (where q=1 – p), with an alpha of 0.05 and an allowable error (e) of 0.05%. Using the formula: $n \geq (Z_{95}\%\ \text{CI})^2 \times p \times q / e^2$, which yielded $(3.84 \times 0.29 \times 0.72) / 0.01 = 80$ participants.

Data Collection Tools- Data were collected using a standardized and pre-validated proforma designed for the study. The proforma captured patient demographics (age and gender), detailed wound characteristics (type, size, and location), serial

wound surface area measurements using the graph paper method, frequency of dressing changes, duration of hospital stay, rate of granulation tissue formation, rate of wound edge contraction, time taken to prepare the wound bed for further surgical intervention, incidence of wound contamination or infection (assessed clinically and by wound swab culture when indicated), total cost of treatment, complications, and final mode of healing (secondary intention, secondary suturing, split skin grafting, or flap repair). Wound improvement was objectively assessed using the revised photographic wound assessment tool and ASEPSIS wound scoring system. Photographic documentation was performed during each dressing change to monitor wound progression. Cost analysis included documentation of materials used (sponge foam, suction devices, dressings, adhesive tapes) and frequency of dressing changes to evaluate cost-effectiveness.

Data Collection Procedure- Patients meeting the inclusion criteria were enrolled within 24 hours of admission to the surgical ward after obtaining written informed consent. A detailed history and thorough physical examination were conducted as per the study proforma. Following wound debridement and achievement of hemostasis, baseline wound measurements were recorded using the graph paper imprint method. In the experimental group, modified vacuum-assisted wound closure was applied using autoclaved sponge foam, suction catheter, and locally available vacuum-generating devices (portable suction, Romovac, or syringe), with negative pressure ranging from −75 to −200 mmHg. The wound was sealed with a sterile polyethylene cover or surgical glove. The control group received conventional dressings as per standard protocol. Dressings were changed every 48–72 hours based on wound condition and exudate. During each change, wound measurements and photographs were recorded, and wound scores were assessed. Treatment continued until adequate granulation tissue formation was achieved, after which definitive wound closure was performed when indicated.

Statistical Analysis- The data collected in this study were analyzed using appropriate statistical methods. Descriptive statistics were applied to summarize the findings. Continuous variables were expressed as mean ± standard deviation (SD) or median with range, as appropriate, while categorical variables were presented as frequencies and percentages. Comparative analysis between the case (modified vacuum-assisted closure) and control (conventional dressing) groups was performed using Student's t-test for continuous variables and the chi-square test or Fisher's exact test for categorical variables, depending on the data distribution and expected cell counts. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Variable	Control (N=40)	Experimental (N=40)	P-Value
Mean Age (in years)	46.28 ± 9.67	42.85 ± 7.89	0.09
Male	31 (77.5%)	33 (82.5%)	0.781
Female	9 (22.5%)	7 (17.5%)	
Diabetes Mellitus	12 (30%)	20 (50%)	0.110
Hypertension	22 (55%)	18 (45%)	0.503

Table 1: Baseline Demographic and Clinical Characteristics

Table 1 show that both groups were comparable at baseline with no statistically significant differences in age, gender, diabetes, or hypertension ($p > 0.05$).

Variable	Control (N=40)	Experimental (N=40)	P-Value
Initial Wound Area (cm^2)	151.08 ± 23.88	162.90 ± 90.54	0.432
Initial Wound Score	21.05 ± 3.31	22.28 ± 4.14	0.148
Diabetic Ulcer	10 (25%)	15 (37.5%)	
Post-debridement	14 (35%)	12 (30%)	
Pressure Ulcer	8 (20%)	6 (15%)	0.702
Neuropathic Ulcer	4 (10%)	5 (12.5%)	
Burn	4 (10%)	2 (5%)	

Table 2: Wound Characteristics at Baseline

Table 2 illustrates that the wound types and baseline wound severity were statistically comparable between groups.

Parameter	Control	Experimental	P-Value
Final Wound Area (cm^2)	141.18 ± 19.43	111.23 ± 64.29	0.006
Final Wound Score	8.60 ± 2.06	6.55 ± 2.30	<0.001

Table 3: Wound Healing Outcomes

Table 3 demonstrates significantly greater wound reduction and better wound score improvement in the modified VAC group.

Parameter	Control	Experimental	P-Value
No. of Debridements	2.85 ± 1.41	1.35 ± 1.39	<0.001
No. of Dressings	26.85 ± 10.27	10.23 ± 4.57	<0.001
Table 4: Procedural Parameters			

Table 4 shows that the experimental group required significantly fewer debridements and dressing changes.

Parameter	Control	Experimental	P-Value
Hospital Stay (days)	38.55 ± 14.30	31.83 ± 11.98	0.025
Pain Score (VAS)	3.35 ± 0.95	3.50 ± 0.82	0.451
Table 5: Hospital Stay and Pain			

Table 5 illustrates significantly shorter hospital stays in the VAC group, while pain scores were comparable.

Culture	Outcome	Control	Experimental	P-Value
Culture 1	No Growth	1 (2.5%)	1 (2.5%)	0.435
Culture 2	No Growth	8 (20%)	10 (25%)	0.526
Culture 3	No Growth	16 (40%)	24 (60%)	0.440
Table 6: Microbiological Culture Progression				

Table 6 shows progressive bacterial clearance in both groups, with a higher proportion of sterile cultures in the experimental group by Culture 3.

Parameter	Control	Experimental	P-Value
Maceration	0	1 (2.5%)	1.000
Split Skin Graft	31 (77.5%)	24 (60%)	
Secondary Intention	9 (22.5%)	16 (40%)	0.147
Table 7: Complications and Mode of Healing			

Table 7 demonstrates minimal complications and a higher trend toward secondary intention healing in the VAC group.

Discussion

Demographic Profile- Both groups were well-matched at baseline for age, gender, comorbidities, wound type, and location ($p > 0.05$ for all). Mean age was 46.28 ± 9.67 years (control) and 42.85 ± 7.89 years (experimental). Males predominated in both groups (77.5% vs. 82.5%) and diabetes mellitus was present in 30% and 50%, respectively. A similar demographic profile with male predominance and high diabetes prevalence has been consistently reported in comparable studies examining VAC versus conventional dressings.[9,10]

Rate of Wound Healing- Initial wound areas were comparable between groups (Control: 151.08 ± 23.88 cm²; Experimental: 162.90 ± 90.54 cm²; $p = 0.432$). At the end of treatment, the modified VAC group demonstrated significantly greater wound area reduction (final area: 111.23 ± 64.29 cm²) compared to controls (141.18 ± 19.43 cm²; $p = 0.006$), with a significantly better final wound score (6.55 ± 2.30 vs. 8.60 ± 2.06; $p < 0.001$). These findings are consistent with published literature. James S et al., reported 65.2% wound size reduction with VAC versus 40.5% with conventional dressings. Mooghal M et al.,[11] documented significantly shorter mean healing time with VAC (12.07 days vs. 17.50 days; $p = 0.0001$). James SMD et al.,[12] found a higher granulation rate (2.91 cm²/day vs. 2.16 cm²/day) and shorter time to heal (22.52 days vs. 33.85 days; $p = 0.0306$) with VAC. Janugade HB et al.,[13] reported mean healing of 27.70 ± 9.57 days with VAC versus 41.93 ± 11.58 days with conventional dressings. Lavery LA et al.,[14] demonstrated a significantly higher successful endpoint rate at 12 weeks with NPWT (39.5% vs. 23.9%; $p < 0.001$). Collectively, these results confirm the superiority of even a cost-modified VAC system in promoting wound healing.

Frequency of Dressing Changes- The modified VAC group required significantly fewer dressing changes (10.23 ± 4.57) compared to controls (26.85 ± 10.27; $p < 0.001$), representing a near-threefold reduction with direct implications for patient comfort, nursing workload, and material costs. Kumar B et al.,[15] reported a significant reduction in dressing frequency with VAC in necrotizing fasciitis

wounds. Janugade HB et al.,[13] noted VAC dressings required changing only every 48 hours versus multiple daily changes with conventional dressings. James S et al.,[12] identified fewer dressing changes as a primary driver of VAC's cost-effectiveness advantage. Devanshu Sojitra et al.,[16] found that the majority of VAC-treated patients achieved wound closure within approximately six weeks with fewer overall changes. These observations align closely with our findings, indicating that an indigenously modified VAC system substantially reduces dressing change frequency in resource-limited settings.

Granulation Bed Preparation for Surgical Intervention- The experimental group required significantly fewer debridements (1.35 ± 1.39 vs. 2.85 ± 1.41; $p < 0.001$), reflecting superior wound-bed optimisation with modified VAC. Although the mode of healing did not differ significantly ($p = 0.147$), a clinically meaningful trend was observed: 40% of VAC-treated patients healed by secondary intention versus 22.5% in controls, suggesting better-prepared granulation beds enabling spontaneous closure in a greater proportion. Lone AM et al.,[17] demonstrated complete granulation in 77.78% of VAC patients by Week 5 versus only 40% with conventional dressings. Karthikeyan S et al.,[18] found 90% granulation coverage at Day 3 with VAC versus 60% in controls. James SMD et al reported 75–100% granulation achieved in 23.33 days with VAC versus 32.15 days conventionally ($p < 0.0001$). Janugade HB et al.,[13] documented significantly higher graft uptake with VAC (82.23% vs. 70.07%) and a shorter minimum healing time (11 days vs. 22 days). Kumar B et al.,[15] also noted earlier granulation and readiness for skin grafting with VAC. These findings collectively affirm the role of modified VAC in accelerating wound bed preparation and reducing the need for repeated surgical interventions.

Rate of Wound Edge Contraction- Wound edge contraction is mechanistically driven by the sub-atmospheric pressure of NPWT, which generates microdeformation forces that physically draw wound margins together.[19] In this study, the VAC group demonstrated significantly greater wound area reduction (162.90 cm^2 to 111.23 cm^2) compared to controls (151.08 cm^2 to 141.18 cm^2), with statistically significant differences in final wound area ($p = 0.006$) and final wound score ($p < 0.001$). Pandey A et al.,[10] and James S et al.,[12] both reported significantly greater percentage reductions in wound dimensions with VAC, corroborating these findings. The consistent wound area and score superiority across studies confirms the efficacy of modified VAC in promoting wound edge contraction.

Minimisation of Wound Contamination- Serial microbiological cultures showed no statistically significant inter-group differences at Culture 1 ($p = 0.435$) or Culture 2 ($p = 0.526$). However, by Culture 3, the experimental group demonstrated a higher proportion of "No Growth" results (60% vs. 40%), though this did not reach statistical significance ($p = 0.440$). This directional trend is biologically consistent with the sealed VAC dressing mechanism, which limits exogenous bacterial contamination and facilitates removal of infected exudate through continuous negative pressure drainage. Kumar B et al.,[15] observed significant reductions in wound odour, peri-wound maceration, and signs of infection with VAC. Lone AM et al.,[17] reported fewer positive blood cultures in the VAC group. James SMD et al.,[12] found no significant increase in infection rate with VAC versus conventional dressings. B. Suresh Kumar et al.,[20] documented reduced overall complication risk, including infectious complications. Although statistical significance was not achieved in the present study, the consistent directional trend towards better bacterial clearance with modified VAC aligns with the established evidence base.

Reduction in Duration of Hospital Stay- The modified VAC group had a significantly shorter mean hospital stay (31.83 ± 11.98 days) compared to controls (38.55 ± 14.30 days; $p = 0.025$) - a difference of approximately one week with meaningful clinical and economic implications. Janugade HB et al.,[13] reported a minimum hospital stay of 13 days with VAC versus 24 days with conventional dressings. Singh J et al.,[12] identified shorter hospital stays as a key determinant of VAC's cost-effectiveness. Mooghal M et al.,[11] demonstrated significantly reduced mean healing time with VAC (12.07 ± 2.15 days vs. 17.50 ± 3.16 days; $p = 0.0001$). Kumar B et al attributed shorter hospitalisation with VAC to faster wound resolution and earlier readiness for surgical intervention. Devanshu Sojitra et al.,[16] found that VAC-treated patients achieved wound closure within approximately six weeks, substantially shorter than conventionally managed cases. These findings are consistent with the present study, confirming that indigenously modified VAC achieves a statistically significant reduction in hospital stay.

Pain Score and Maceration- VAS pain scores were comparable between groups at assessment (control: 3.35 ± 0.95 vs. experimental: 3.50 ± 0.82; $p = 0.451$), indicating no additional pain burden with modified VAC. Notably, the significantly fewer dressing changes in the VAC group imply reduced cumulative exposure to procedure-related pain events. James SMD et al.,[12] demonstrated significantly lower pain scores in the VAC group at Week 3 of serial assessment (VAS 3 vs. 4; $p = 0.004$). Peri-wound maceration was observed in only 1 patient (2.5%) in the experimental group and none in the control group ($p = 1.000$), confirming the safety profile of the modified VAC system and its

efficacy in managing wound exudate without causing peri-wound skin damage.

The present study demonstrates that an indigenously modified vacuum wound closure device-constructed using locally available materials-achieves superior clinical outcomes compared to conventional dressings across multiple wound healing parameters. Significantly greater wound area reduction and wound score improvement, a near-threefold reduction in dressing change frequency, markedly fewer debridements, a trend toward greater secondary-intention healing, directionally improved bacterial clearance, and a significantly shorter hospital stay were all demonstrated. These findings are consistent across reviewed literature and validate the clinical efficacy of a cost-modified VAC system in resource-constrained settings. The results reinforce the growing evidence base supporting NPWT as a standard of care for complex wound management and demonstrate that its benefits can be extended to settings that cannot afford commercial systems, with meaningful potential to improve wound care outcomes in low- and middle-income healthcare environments.

CONCLUSION

The present comparative study demonstrates that an indigenously modified vacuum-assisted wound closure system is significantly superior to conventional dressings in the management of complex wounds. The modified VAC group showed greater wound area reduction, lower final wound scores, fewer debridements, markedly reduced dressing frequency, and a significantly shorter hospital stay, confirming enhanced healing efficacy and practical advantages. The system, constructed using locally available materials such as portable suction devices, surgical gloves, Opsite, and plastic covers, proved to be safe with minimal complications and showed a trend toward improved bacterial clearance. Overall, this cost-effective and feasible modification offers a clinically effective alternative to conventional dressings, particularly suited for resource-limited healthcare settings.

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How to cite this article: Dr. B.P. Sanganal, Dr. Sangeetha Kalabhairav, Dr. Jyothi U.S., Dr. Srijika Bhattacharyya, Dr. Vinayak P. Hosamani, Dr. Bhavish Rai, A MODIFICATION OF VACUUM-ASSISTED WOUND CLOSURE VERSUS CONVENTIONAL DRESSING: A COMPARATIVE STUDY, Asian J. Med. Res. Health Sci., 2026; 4 (1):510-516.
Source of Support: Nil, Conflicts of Interest: None declared.