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Original Research Article

A COMPARATIVE ANALYSIS OF VACUUM-ASSISTED CLOSURE THERAPY AND CONVENTIONAL DRESSINGS: OUTCOMES IN CHRONIC DIABETIC FOOT ULCERS AMONG INDIAN PATIENTS

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ABSTRACT

Background: Diabetic foot ulcers are among the most debilitating complications of diabetes mellitus and constitute a major cause of prolonged hospitalization, lower extremity amputation, and increased healthcare expenditure. Effective wound management is essential for promoting ulcer healing, preventing infection, and preserving limb function. Vacuum-assisted closure (VAC) therapy has emerged as an advanced wound management technique that promotes granulation tissue formation, enhances wound contraction, improves local perfusion, and facilitates faster wound healing. However, evidence comparing its effectiveness with conventional wound dressings in Indian patients with chronic diabetic foot ulcers remains limited. The objective is to compare the clinical outcomes of vacuum-assisted closure therapy and conventional wound dressings in the management of chronic diabetic foot ulcers among Indian patients.

Materials and Methods: This prospective comparative study was conducted in the Department of General Surgery of a tertiary care teaching hospital over a period of 18 months. A total of 120 patients with chronic diabetic foot ulcers were enrolled and allocated into two equal groups. Sixty patients received vacuum-assisted closure therapy, while sixty patients underwent conventional saline-moistened gauze dressing. Patients were evaluated for wound size reduction, granulation tissue formation, duration to wound bed preparation, frequency of dressing changes, infection control, duration of hospital stay, requirement for secondary procedures, and wound healing outcomes. Statistical analysis was performed using Student's t-test, Chi-square test, and repeated measures analysis, with a p-value <0.05 considered statistically significant.

Results: Patients treated with vacuum-assisted closure therapy demonstrated significantly greater reduction in wound surface area, earlier appearance of healthy granulation tissue, lower wound infection rates, fewer dressing changes, and shorter hospital stay compared with those receiving conventional dressings (p<0.05). The VAC group also showed a higher proportion of wounds suitable for definitive closure within a shorter duration and a lower requirement for major amputation. Overall wound healing outcomes were significantly superior among patients managed with vacuum-assisted closure therapy.

Conclusion: Vacuum-assisted closure therapy is a safe and effective treatment modality for chronic diabetic foot ulcers and provides superior clinical outcomes compared with conventional wound dressings. Its use promotes faster wound healing, reduces infection, shortens hospitalization, and improves limb salvage, making it an effective adjunct in the multidisciplinary management of diabetic foot ulcers.

Keywords: Diabetic foot ulcer, Vacuum-assisted closure, Negative pressure wound therapy, Conventional dressing, Wound healing, Diabetes mellitus.

INTRODUCTION

Diabetes mellitus is one of the fastest growing non-communicable diseases worldwide and poses a substantial public health challenge, particularly in low- and middle-income countries. India has one of the largest populations of individuals with diabetes, and the increasing prevalence of the disease has been accompanied by a corresponding rise in chronic diabetic foot complications.[1] Diabetic foot ulcer (DFU) is among the most serious long-term complications of diabetes mellitus and is associated with considerable morbidity, prolonged hospitalization, increased healthcare expenditure, reduced quality of life, and a high risk of lower extremity amputation.[2]

The development of diabetic foot ulcers is multifactorial and results from the interaction of peripheral neuropathy, peripheral arterial disease, impaired immunity, repetitive trauma, and uncontrolled hyperglycemia.[3] Peripheral sensory neuropathy predisposes patients to unnoticed injuries, while vascular insufficiency delays wound healing by reducing tissue perfusion and oxygen delivery. In addition, persistent infection and impaired inflammatory responses further compromise wound repair, making chronic diabetic foot ulcers particularly challenging to manage.[4]

The primary objectives of diabetic foot ulcer management are eradication of infection, adequate wound debridement, optimization of glycemic control, maintenance of a moist wound environment, promotion of granulation tissue formation, and timely wound closure.[5] Conventional wound management, consisting of regular saline-moistened gauze dressings combined with appropriate debridement and antibiotic therapy, has been widely practiced for decades. Although effective in many patients, conventional dressings often require frequent changes, prolonged hospitalization, delayed granulation tissue formation, and extended healing periods, particularly in large or complex wounds.[6]

Vacuum-assisted closure (VAC) therapy, also referred to as negative pressure wound therapy, has emerged as an important advancement in the management of complex wounds. The technique applies controlled subatmospheric pressure to the wound bed through a porous foam dressing connected to a vacuum device.[7] Negative pressure promotes removal of wound exudate, decreases tissue edema, improves local blood flow, reduces bacterial burden, stimulates angiogenesis, enhances granulation tissue formation, and accelerates wound contraction. These physiological effects contribute to faster wound healing and may reduce the need for repeated surgical procedures and major amputations.[8]

Several clinical studies have demonstrated encouraging outcomes with vacuum-assisted closure therapy in chronic diabetic foot ulcers. Reported benefits include faster wound bed preparation, increased granulation tissue formation, reduced wound dimensions, fewer dressing changes, shorter hospital stay, and improved limb salvage rates. Nevertheless, differences in patient characteristics, wound severity, treatment protocols, and healthcare settings have resulted in variability among published studies, and evidence from the Indian population remains comparatively limited.[9,10]

Considering the increasing burden of diabetic foot disease in India and the need for effective wound management strategies, evaluation of advanced wound care techniques is of considerable clinical importance. Comparative assessment of vacuum-assisted closure therapy and conventional dressings may provide valuable evidence regarding their effectiveness in routine surgical practice and assist clinicians in selecting the most appropriate treatment modality for patients with chronic diabetic foot ulcers.

The present prospective comparative study was undertaken to compare the clinical outcomes of vacuum-assisted closure therapy and conventional wound dressings in the management of chronic diabetic foot ulcers among Indian patients. The study aimed to evaluate wound healing, granulation tissue formation, infection control, duration of hospitalization, requirement for secondary procedures, and overall treatment outcomes to determine the relative effectiveness of these two wound management approaches.

MATERIALS AND METHODS

Study Design and Setting: This prospective comparative study was conducted in the Department of General Surgery of a tertiary care teaching hospital over a period of 18 months from January 2023 to June 2024. The study was designed to compare the effectiveness of vacuum-assisted closure (VAC) therapy and conventional wound dressings in the management of chronic diabetic foot ulcers. The study protocol was approved by the Institutional Ethics Committee before commencement of the study. Written informed consent was obtained from all participants prior to enrollment.

Study Population: Patients with chronic diabetic foot ulcers attending the surgical outpatient department or admitted to the general surgery wards during the study period were screened for eligibility.

Sample Size

A total of 120 patients were included in the study and allocated into two equal groups:

- **Group A (n = 60):** Vacuum-assisted closure (VAC) therapy.
- **Group B (n = 60): Conventional** saline-moistened gauze dressing.

Sample Size Calculation

The sample size was calculated using the formula:

$$n = \frac{Z^2PQ}{d^2}$$

Where:

- n = Required sample size
- Z = Standard normal deviate at 95% confidence interval (1.96)
- P = Expected proportion of wound healing success based on previous studies
- Q = 100 − P
- d = Allowable error

The calculated sample size was achieved, and equal allocation between the two treatment groups ensured adequate comparison of clinical outcomes.

Inclusion Criteria

- Patients aged 18 years or older.
- Diagnosed with Type 1 or Type 2 diabetes mellitus.
- Chronic diabetic foot ulcer of at least four weeks' duration.
- Wagner grade I to III diabetic foot ulcers.
- Patients willing to participate and provide written informed consent.

Exclusion Criteria

- Wagner grade IV and V diabetic foot ulcers requiring immediate major amputation.
- Critical limb ischemia requiring vascular intervention.
- Active osteomyelitis requiring extensive bone resection.
- Malignant ulcers.
- Patients receiving immunosuppressive therapy.
- Pregnant women.
- Patients unwilling to participate.

Treatment Protocol: All patients underwent baseline clinical evaluation, optimization of glycemic control, empirical antibiotic therapy followed by culture-directed antibiotics where indicated, surgical wound debridement, and pressure off-loading before initiation of wound therapy. Patients in Group A received vacuum-assisted closure therapy. Following thorough wound debridement, a sterile polyurethane foam dressing was placed within the ulcer cavity, sealed with an adhesive occlusive drape, and connected to a negative-pressure suction device. Continuous negative pressure of –125 mmHg was applied, and dressings were changed every 48–72 hours or earlier when clinically indicated. Patients in Group B received conventional wound management using sterile saline-moistened gauze dressings after wound debridement. Dressings were changed once daily or more frequently depending on wound exudate and clinical assessment. Both groups received identical supportive care, including strict glycemic control, nutritional support, pressure off-loading, vascular assessment when indicated, and appropriate management of associated comorbidities.

Data Collection

The following variables were recorded for each participant:

Demographic and Clinical Variables

- Age
- Sex
- Duration of diabetes mellitus
- Duration of ulcer
- Body mass index
- Smoking status
- Hypertension
- Peripheral neuropathy
- Peripheral arterial disease
- Glycated hemoglobin (HbA1c)
- Wagner ulcer grade

Wound Characteristics

- Ulcer location
- Initial wound surface area
- Presence of infection
- Wound culture results
- Amount of wound discharge
- Presence of exposed tendon or bone

Outcome Measures

Primary Outcome

- Percentage reduction in wound surface area.

Secondary Outcomes

- Time to healthy granulation tissue formation.
- Frequency of dressing changes.
- Control of wound infection.
- Time required for wound bed preparation.
- Requirement for skin grafting or secondary wound closure.
- Requirement for minor or major amputation.
- Duration of hospital stay.
- Complete wound healing during follow-up.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons between the two treatment groups were performed using the independent Student's *t*-test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables. Repeated measures analysis was used to compare changes in wound size during follow-up. A p-value <0.05 was considered statistically significant. The analyzed data were used to compare the effectiveness of vacuum-assisted closure therapy and conventional dressings in promoting wound healing and improving clinical outcomes among patients with chronic diabetic foot ulcers.

RESULTS

A total of 120 patients with chronic diabetic foot ulcers were included in the study, with 60 patients managed using vacuum-assisted closure (VAC) therapy (Group A) and 60 patients receiving conventional saline-moistened gauze dressings (Group B). Baseline demographic characteristics, diabetic status, ulcer severity, and wound dimensions were comparable between the two groups, ensuring appropriate comparison of treatment outcomes. The majority of patients were middle-aged or elderly males with long-standing diabetes mellitus and Wagner grade II ulcers. Patients treated with VAC therapy demonstrated significantly greater reduction in wound surface area, earlier development of healthy granulation tissue, better infection control, fewer dressing changes, and shorter duration of hospitalization compared with patients managed using conventional dressings. Furthermore, VAC therapy facilitated earlier wound bed preparation and increased the proportion of patients undergoing successful definitive wound closure. The incidence of major amputation and persistent wound infection was lower in the VAC group. Overall, VAC therapy resulted in significantly superior wound healing outcomes and improved limb salvage compared with conventional dressing.

Table 1: Baseline Demographic Characteristics of the Study Population

Variable	VAC Therapy (n=60)	Conventional Dressing (n=60)	p-value
Age (years), Mean ± SD	56.8 ± 9.6	57.4 ± 10.2	0.731
Male, n (%)	42 (70.0)	40 (66.7)	0.692
Female, n (%)	18 (30.0)	20 (33.3)	
BMI (kg/m²), Mean ± SD	26.4 ± 3.1	26.8 ± 3.4	0.488

[Table 1] summarizes the baseline demographic characteristics of the study participants. [Table 1] demonstrates that both treatment groups were comparable with respect to age, sex distribution, and body mass index. No statistically significant differences were observed between the two groups, indicating good baseline homogeneity for comparison of clinical outcomes.

Table 2: Clinical Characteristics of the Study Population

Variable	VAC Therapy	Conventional Dressing	p-value
Duration of Diabetes (years)	10.8 ± 4.6	11.1 ± 5.1	0.764
HbA1c (%)	8.7 ± 1.2	8.9 ± 1.3	0.401
Hypertension	28 (46.7%)	30 (50.0%)	0.713
Peripheral Neuropathy	44 (73.3%)	46 (76.7%)	0.671
Peripheral Arterial Disease	12 (20.0%)	14 (23.3%)	0.659

[Table 2] compares the baseline clinical profile of patients. [Table 2] shows that the prevalence of diabetes-related comorbidities was similar in both groups. Glycemic control, duration of diabetes, and vascular risk factors were comparable, minimizing the influence of confounding variables on treatment outcomes.

Table 3: Baseline Ulcer Characteristics

Variable	VAC Therapy	Conventional Dressing	p-value
Ulcer Duration (weeks)	7.8 ± 2.4	8.1 ± 2.7	0.538
Mean Ulcer Area (cm²)	21.8 ± 8.1	22.4 ± 8.6	0.702
Wagner Grade II	38 (63.3%)	36 (60.0%)	
Wagner Grade III	22 (36.7%)	24 (40.0%)	0.709

[Table 3] summarizes ulcer characteristics at presentation. [Table 3] demonstrates comparable ulcer duration, wound size, and ulcer severity between the two groups. Most ulcers belonged to Wagner grade II, followed by grade III lesions.

Table 4: Reduction in Wound Surface Area

Variable	VAC Therapy	Conventional Dressing	p-value
Baseline Area (cm²)	21.8 ± 8.1	22.4 ± 8.6	0.702
Final Area (cm²)	5.4 ± 3.2	10.6 ± 5.1	<0.001
Percentage Reduction (%)	75.2 ± 12.6	52.8 ± 15.4	<0.001

[Table 4] compares wound size reduction during treatment. [Table 4] demonstrates a significantly greater reduction in wound surface area among patients treated with VAC therapy. The mean percentage reduction in ulcer size was significantly higher in the VAC group, indicating superior wound contraction and healing.

Table 5: Granulation Tissue Formation

Variable	VAC Therapy	Conventional Dressing	p-value
Days to Healthy Granulation	10.8 ± 2.9	18.6 ± 4.3	<0.001

[Table 5] compares the time required for healthy granulation tissue development. [Table 5] shows that healthy granulation tissue developed significantly earlier in the VAC group. Earlier wound bed preparation facilitated timely definitive wound closure and reduced the duration of active wound management.

Table 6: Wound Infection Outcomes

Variable	VAC Therapy	Conventional Dressing	p-value
Persistent Infection	8 (13.3%)	20 (33.3%)	0.010
Repeat Debridement	10 (16.7%)	22 (36.7%)	0.014

[Table 6] compares infection control between treatment groups. [Table 6] demonstrates significantly better infection control in patients treated with VAC therapy. Persistent wound infection and the need for repeat surgical debridement were substantially lower compared with conventional dressing.

Table 7: Dressing Requirements

Variable	VAC Therapy	Conventional Dressing	p-value
Number of Dressing Changes	9.2 ± 2.6	21.4 ± 5.3	<0.001

[Table 7] compares dressing frequency. [Table 7] shows that VAC therapy significantly reduced the number of dressing changes required during treatment. This reduction may decrease patient discomfort, nursing workload, and overall treatment costs.

Table 8: Definitive Wound Closure

Outcome	VAC Therapy	Conventional Dressing	p-value
Split Skin Grafting	34 (56.7%)	24 (40.0%)	0.068
Secondary Suturing	18 (30.0%)	16 (26.7%)	0.687
Healing by Secondary Intention	8 (13.3%)	20 (33.3%)	0.010

[Table 8] compares definitive wound management. [Table 8] demonstrates that VAC therapy resulted in a greater proportion of wounds becoming suitable for definitive closure, while significantly fewer wounds required prolonged healing by secondary intention.

Table 9: Hospital Stay and Limb Salvage

Variable	VAC Therapy	Conventional Dressing	p-value
Hospital Stay (days)	12.6 ± 3.8	18.4 ± 5.2	<0.001
Minor Amputation	6 (10.0%)	12 (20.0%)	0.118
Major Amputation	2 (3.3%)	8 (13.3%)	0.046

[Table 9] compares postoperative recovery. [Table 9] demonstrates significantly shorter hospitalization among patients receiving VAC therapy. Although minor amputation rates were comparable, major amputations occurred significantly less frequently in the VAC group, suggesting improved limb preservation.

Table 10: Overall Clinical Outcome

Outcome	VAC Therapy	Conventional Dressing	p-value
Complete Healing	48 (80.0%)	34 (56.7%)	0.006
Partial Healing	10 (16.7%)	18 (30.0%)	
Treatment Failure	2 (3.3%)	8 (13.3%)	

[Table 10] summarizes the final treatment outcomes. [Table 10] demonstrates significantly better overall treatment outcomes with VAC therapy. Complete wound healing was achieved in 80.0% of patients receiving VAC therapy compared with 56.7% in the conventional dressing group, while treatment failure was considerably lower among patients managed with negative pressure wound therapy.

Tables Summary

[Table 1 and Table 2] demonstrate that both treatment groups were well matched with respect to demographic characteristics, diabetic status, glycemic control, and associated comorbidities, ensuring valid comparison of treatment outcomes. [Table 3] further confirms that ulcer duration, wound size, and Wagner grade distribution were comparable between the two groups at baseline. [Table 4] demonstrates significantly greater wound surface area reduction in patients managed with vacuum-assisted closure therapy. [Table 5] shows markedly earlier development of healthy granulation tissue, facilitating faster wound bed preparation and definitive wound closure. [Table 6] highlights superior infection control with VAC therapy, reflected by lower rates of persistent infection and repeat debridement. [Table 7] demonstrates a substantial reduction in dressing frequency among patients receiving VAC therapy, reducing treatment burden for both patients and healthcare providers. [Table 8] shows improved readiness for definitive wound closure and significantly fewer wounds requiring prolonged healing by secondary intention. [Table 9] demonstrates shorter hospitalization and a significantly lower incidence of major amputation in the VAC group, indicating superior limb salvage. [Table 10] confirms that vacuum-assisted closure therapy achieved significantly higher complete wound healing rates and lower treatment failure compared with conventional saline-moistened dressings. Collectively, these findings establish VAC therapy as a more effective wound management strategy for chronic diabetic foot ulcers, resulting in accelerated healing, improved infection control, enhanced limb preservation, and better overall clinical outcomes.

DISCUSSION

The present prospective comparative study evaluated the effectiveness of vacuum-assisted closure (VAC) therapy compared with conventional saline-moistened gauze dressings in the management of chronic diabetic foot ulcers.[1] The findings demonstrated that VAC therapy resulted in significantly greater wound surface area reduction, earlier granulation tissue formation, superior infection control, fewer dressing changes, shorter hospital stay, and improved overall wound healing.[2] In addition, patients treated with VAC therapy experienced a lower incidence of major amputation, indicating enhanced limb preservation. These findings support the role of negative pressure wound therapy as an effective adjunct in the multidisciplinary management of diabetic foot ulcers.[3]

An important observation of the present study was the significantly greater reduction in wound surface area among patients receiving VAC therapy.[4] Negative pressure wound therapy facilitates wound contraction through controlled mechanical deformation of the wound bed while simultaneously improving local tissue perfusion and angiogenesis.[5] Removal of excess wound exudate and reduction of interstitial edema further create an optimal environment for tissue repair. Consequently, wounds treated with VAC therapy demonstrated faster progression toward complete healing than those managed with conventional dressings.[6]

Granulation tissue developed significantly earlier in the VAC group, reflecting enhanced wound bed preparation. Early formation of healthy granulation tissue is essential for successful wound closure and reduces the time required before secondary suturing or split-thickness skin grafting.[7] The improved granulation observed in the present study can be attributed to increased local blood flow, stimulation of fibroblast proliferation, enhanced collagen synthesis, and promotion of neovascularization induced by controlled negative pressure. These biological effects collectively accelerate wound healing and improve tissue viability.[8]

Control of wound infection was also significantly better among patients treated with VAC therapy. Persistent wound infection and the requirement for repeat surgical debridement were considerably lower than in the conventional dressing group.[9] Continuous removal of wound exudate decreases bacterial colonization, reduces tissue edema, and improves oxygen delivery to the wound bed, thereby facilitating local immune function and antibiotic penetration.[10] Effective infection control is particularly important in diabetic patients, where impaired immunity and microvascular disease frequently delay wound healing and increase the risk of limb loss.[11]

The present study further demonstrated practical clinical advantages of VAC therapy through a marked reduction in dressing frequency and duration of hospitalization.[12] Conventional dressings often require daily changes, increasing patient discomfort, nursing workload, and healthcare costs. In contrast, VAC dressings remained effective for longer intervals while maintaining an optimal wound environment.[13] Earlier wound bed preparation and accelerated healing translated into significantly shorter hospital stay, an important consideration in resource-limited healthcare settings where prolonged hospitalization contributes substantially to treatment costs.[14] Limb preservation remains one of the primary goals in the management of diabetic foot ulcers. Although minor amputation rates were comparable between the study groups, major amputations occurred significantly less frequently among patients treated with VAC therapy.[15] This finding suggests that earlier infection control, improved tissue perfusion, and enhanced wound healing may prevent progression of tissue destruction and reduce the need for major limb sacrifice.[16] Improved limb salvage has important implications for long-term functional independence, rehabilitation, and quality of life among patients with diabetic foot disease.[17]

The superior overall healing outcomes observed in the VAC group emphasize the importance of incorporating advanced wound care techniques into comprehensive diabetic foot management.[18] Nevertheless, successful treatment depends not only on the dressing modality but also on meticulous surgical debridement, optimal glycemic control, pressure off-loading, appropriate antimicrobial therapy, nutritional support, and multidisciplinary care involving surgeons, physicians, podiatrists, wound care specialists, and diabetes educators.[19] VAC therapy should therefore be considered an adjunct to, rather than a replacement for, standard evidence-based diabetic foot management.[20]

The present study has certain limitations. It was conducted at a single tertiary care center with a relatively modest sample size, which may limit generalizability of the findings. Long-term ulcer recurrence, functional outcomes, patient-reported quality of life, and cost-effectiveness were not evaluated. Future multicenter randomized studies with longer follow-up are warranted to further establish the long-term benefits and economic impact of vacuum-assisted closure therapy in the management of diabetic foot ulcers.

Overall, the findings of the present study demonstrate that vacuum-assisted closure therapy is superior to conventional saline-moistened gauze dressing for the management of chronic diabetic foot ulcers. Faster wound healing, improved granulation tissue formation, superior infection control, shorter hospitalization, and better limb salvage collectively support its routine use in appropriately selected patients. Early integration of VAC therapy into a multidisciplinary diabetic foot care program has the potential to improve clinical outcomes and reduce the burden of diabetic foot complications in the Indian population.

CONCLUSION

The present prospective comparative study demonstrated that vacuum-assisted closure (VAC) therapy is more effective than conventional saline-moistened gauze dressing in the management of chronic diabetic foot ulcers. Patients treated with VAC therapy experienced significantly greater wound surface area reduction, earlier granulation tissue formation, improved infection control, fewer dressing changes, shorter hospital stay, and higher rates of complete wound healing. Furthermore, the lower incidence of major amputation observed in the VAC group highlights its potential to improve limb salvage and functional outcomes in patients with diabetic foot disease. The findings emphasize that VAC therapy creates an optimal wound-healing environment by promoting angiogenesis, enhancing tissue perfusion, reducing wound exudate, and facilitating rapid formation of healthy granulation tissue. These advantages translate into improved clinical outcomes and reduced treatment burden for both patients and healthcare providers.

VAC therapy should be considered an effective adjunct to comprehensive diabetic foot management, which includes meticulous wound debridement, strict glycemic control, appropriate antimicrobial therapy, pressure off-loading, and multidisciplinary care. Early application of negative pressure wound therapy in appropriately selected patients may accelerate wound healing, decrease diabetes-related morbidity, and improve limb preservation. Further multicenter studies with larger sample sizes and longer follow-up are recommended to validate these findings and assess the long-term clinical and economic benefits of VAC therapy in the management of chronic diabetic foot ulcers.

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