Original Study

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Comparative Evaluation of Wound Healing and Wound Contraction Time in Diabetic Foot Ulcers Treated with Vacuum-assisted Closure and Conventional Dressing

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Abstract

Background: The rising incidence of diabetes mellitus (DM) has led to an increase in severe DM complications, such as diabetic foot ulcers (DFUs). DFUs cause prolonged morbidity, prolonged hospitalization, deep and soft tissue infections, amputations and are associated with high mortality rates. DFUs require meticulous wound care for their effective management and despite the advances made, healing time of the ulcers and recurrence rate continue to be high. Various conventional dressings are used in modern medicine for managing DFU, which include moist dressing (using silver-backed, hydroactive polyurethanes) in addition to advanced dressing. It is often seen that a combination of techniques or therapies is used for better clinical outcome. The novel technique of vacuum-assisted closure (VAC) therapy is another technique that promotes wound healing by removal of air from the wound bed and by reducing wound complications by drawing serum and particulate matter from the surface. VAC therapy enhances angiogenesis and controls infection, leading to a faster rate of healing of DFUs compared to conventional dressing. **Methods:** This study aimed to evaluate and compare VAC dressing with conventional dressing in the management of diabetic wounds about healing time of ulcers, reduction of ulcer area, controlling infection and outcome. This was a hospital-based, prospective observational study conducted in the Department of General Surgery, Muzaffarnagar Medical College, Uttar Pradesh, among 60 patients of diabetic wounds from October 2022 to September 2023. The 60 patients of diabetic wounds were categorized into 2 groups. Thirty patients were treated with vacuum-assisted closure (VAC) and 30 patients with conventional dressings. Patients were randomly assigned to either the VAC dressing group or the conventional dressing group. Wound healing parameters were documented at weekly intervals for 3 months. Statistical analysis was done by applying unpaired Student's t test for continuous variables and chi-square test for categorical variables, with $p < 0.05$ being considered statistically significant. **Results:** In the VAC dressing group, 36.7% of patients were in the age group of 40-49 years, whereas in the conventional dressing group, 33.3% of patients belonged to the same age group. Both groups had similar baseline characteristics. The average initial wound area of diabetic ulcers in both groups was 53.66 ± 7.24 mm² and 48.92 ± 7.98 mm². There was a statistically significant reduction in the final wound area of diabetic ulcers in the VAC group (35.2 ± 6.78 mm²) compared to the conventional group (48.92 ± 7.98 mm²). The mean reduction in wound area was greater in the VAC group (18.44 ± 3.68 mm²) than in the conventional group (7.08 ± 0.85 mm²), emphasizing the efficacy of VAC dressing. The percentage of wound area reduction was greater in the VAC group ($33.8 \pm 3.89\%$) than in the conventional group ($12.89 \pm 1.89\%$). The average duration of wound contracture in the VAC group was 4.47 ± 0.39 weeks compared to the conventional dressing group, where it was 6.14 ± 0.45 weeks. **Conclusion:** The results indicate that the VAC dressing has been more beneficial over conventional dressing for diabetic wounds in terms of wound healing, wound area reduction and control over infection. Given these findings, VAC therapy is strongly recommended as a preferred mode of treatment for diabetic wounds.

Keywords: Diabetic wound, VAC dressing, Vacuum-assisted closure, Wound healing, Diabetic foot Ulcer, Negative-pressure wound therapy

Introduction

Diabetes prevalence is expected to rise by 156% in Africa, 16% in Europe, 35% in North America and the Caribbean, and 84% in Southeast Asia by 2045, according to the International Diabetes Federation (IDF) [1]. As the prevalence of the disease increases, so do the complications, which affect almost all the body's systems. Along with other serious aftereffects, diabetic wounds are a major cause of morbidity and mortality among the overall effects of diabetes [2]. Diabetic wounds are the leading cause of hospitalization and a serious side effect of diabetes mellitus [3]. Diabetic wounds cause 50% to 70% of lower limb amputations and hospitalization for about 50% of diabetic patients. Relative mortality after diabetic wounds is estimated to be 48% after five years [4].

Diabetic foot ulcers (DFU) are one of the consequences of diabetes mellitus (DM), a rapidly expanding global health concern that greatly increases patient morbidity and death. About 19% to 34% of diabetes individuals worldwide suffer from DFU, a serious and common condition that is especially common in India [5]. Effective and creative treatment solutions are required to prevent amputations and

enhance patient outcomes since, despite improvements in wound management procedures, the recurrence and healing time of diabetic wounds have remained virtually unchanged over the past few decades.

Usually, debridement, antibiotic treatment, and traditional dressings are used to treat diabetic wounds. However, new research indicates that by encouraging angiogenesis, improving granulation tissue production, boosting blood circulation, and lowering infection, vacuum-assisted closure (VAC) therapy—which makes use of negative pressure wound therapy—can hasten wound healing [6]. Originally presented by Argenta and Morykwas in 1997, vacuum- assisted closure is a non-pharmacological, non-surgical technique for improving wound healing [7]. With its several operating modes and ability to provide constant and continuous negative pressures, vacuum-assisted closure (VAC) therapy is a cutting-edge type of negative pressure drainage technology. It is necessary to maintain the appropriate negative pressure range of 125 - 200 mm Hg [8]. In spite of the promising results yielded by VAC therapy, conventional dressings remain widely used due to their convenience and popularity; thus, there is a lack of information about their effectiveness when used in comparison with other methods of wound treatment.

The comparative effectiveness of VAC dressing and conventional dressing in diabetic wounds treatment should be investigated deeply because of high costs related to such conditions. In terms of their impact on wound healing, infection control, and overall health state, the aim of this study is to compare the clinical efficacy of both techniques. A comprehensive analysis will provide physicians with valuable information to use the most efficient method of wound treatment among diabetic patients.

Material and Methods

This prospective comparative intervention study was done in the Department of General Surgery at Muzaffarnagar Medical College, Muzaffarnagar, Uttar Pradesh. The study duration was of 18 months in which data was collected for 12 months followed by data analysis for 6 months, i.e., [Nov 2022 to June 2025]. A total of 60 patients with diabetic wounds were enrolled consecutively during the study period.

Patients with chronic diabetic wounds measuring more than 1 cm in diameter and willing to provide written informed consent were included in the study. Patients with evident local infection or gangrene, osteomyelitis on X-ray, positive probe-to-bone test, elevated C-reactive protein, end-stage organ failure, hepatic or renal failure, thrombocytopenia, steroid use, anticoagulant or antiplatelet therapy, ulcers measuring less than 1 cm or more than 8 cm in diameter, ulcers deeper than 2 cm, and lower limb ischemia were excluded. Lower limb ischemia was ruled out clinically by the presence of distal limb pulsations and an ankle-brachial index greater than 0.9.

Following careful history taking and clinical evaluation along with laboratory investigations, surgery for debridement was conducted in all the patients. Two groups were formed with patients randomly allocated to each group: Group A patients were dressed conventionally while Group B patients had vacuum-assisted closure (VAC) dressings. Suitable antimicrobial agents were prescribed to all the patients. A sensitivity test was conducted in both the groups, and antibiotics were changed as per sensitivity reports.

For patients in the VAC group, wound bed preparation included removal of the old dressing, wound irrigation with normal saline, microbiological culture sampling where indicated, minimal surgical debridement of slough or necrotic tissue, achievement of hemostasis, and cleaning of the surrounding skin with alcohol. A sterile polyurethane ether foam dressing was placed within the wound cavity and connected to a regulated vacuum pump through a suction tube as shown in **figure 1**. The wound was then sealed with an iodine-impregnated adhesive drape extending onto the surrounding healthy skin to ensure an airtight seal. Negative pressure of 120-130 mm Hg was applied through the system.

Figure 1: VAC dressing in a patient.

Patients were followed up at regular intervals, and wound size and depth were assessed every 3 weeks for a period of 3 months. The two groups were compared with respect to healing time, wound size reduction, depth reduction, and wound regression in order to evaluate the effectiveness of the two dressing methods in the management of diabetic wounds.

Ethical clearance for the study was obtained from the Institutional Clinical Trial Screening Committee and the Institutional Ethics Committee Ref. No. MMC/IEC/2023/234 dated 20th March 2023. Written informed consent was obtained from all participants, and patient confidentiality was maintained by assigning anonymous identification numbers.

The collected data were entered into Microsoft Excel. Continuous variables were summarized as mean ± standard deviation, while categorical variables were presented as proportions and percentages. The significance of differences between means was assessed using Student's t test, and differences between proportions were analyzed using the chi-square test. A p value of less than 0.05 was considered statistically significant.

Results

The average age of the participants in our study was 48.97±11.39 years for the VAC dressing group and 49.77±9.68 years for the traditional dressing group. The mean age of the two groups did not differ statistically significantly (p>0.05).

With 36.7% of participants in the VAC dressing group and 33.3% in the conventional dressing group, the majority of participants in our study were between the ages of 40 and 49. With minor variations in the 50–59 age group (20.0% in VAC vs. 36.7% in conventional dressing), the age group distribution was comparatively similar in both groups. The age distributions of the two treatment groups did not differ statistically significantly, indicating that the age profiles were similar (p>0.05).

In our study, the distribution of male and female participants was identical in both groups, with 70% males and 30% females in each. The distribution of genders in the two groups did not differ statistically significantly (p>0.05).

Although the VAC dressing group's mean hemoglobin level was marginally lower (11.11 ± 0.86 g/dL) than that of the traditional dressing group (11.62 ± 1.3 g/dL) in our investigation, the difference was not statistically significant (p=0.079). The VAC group's mean fasting blood sugar levels were 110.73 ± 11.07 mg/dL, whereas the traditional group's were 115.73 ± 10.5 mg/dL. There was no significant difference between the two groups (p=0.078). There was no significant difference (p=0.298) in the mean HbA1C values between the two groups (7.86 ± 0.83 vs. 7.65 ± 0.69). The statistical comparison of hemoglobin, fasting blood sugars and HbA1c levels are shown in **Table 1.**

In our study, the initial wound area was comparable in both groups (53.97 ± 8.8 mm² in the VAC group vs. 56.02 ± 8.32 mm² in the conventional group, p=0.359). The final wound area was significantly smaller in the VAC dressing group (35.2 ± 6.78 mm²) compared to the conventional group (48.92 ± 7.98 mm²), with a significant p-value (<0.001). The mean reduction in wound area was significantly higher in the VAC dressing group (18.44 ± 3.68 mm²) compared to the conventional dressing group (7.08 ± 0.85 mm²), showing a highly significant difference (p<0.001).

These findings indicate that VAC dressing was more effective in promoting wound size reduction compared to conventional dressing (**Table 2 and figure 2**). In our study, the percentage of wound area reduction was significantly greater in the VAC dressing group (33.8 ± 3.89%) compared to the conventional dressing group (12.89 ± 1.89%). There was statistically significant difference (p<0.001) between both the study groups **(Table 3).**

In our study, the VAC dressing group experienced wound contracture for an average of 4.47 ± 0.39 weeks, which was

Table 1- Comparison of Haemoglobin, Fasting Blood Sugar, and HbA1C Levels Between VAC Dressing and Conventional Dressing Groups

Variable	VAC dressing		Conventional Dressing		Test of significance	
	Mean	SD	Mean	SD	t value	p value
Haemoglobin	11.11	0.86	11.62	1.3	1.79	0.079
Fasting Blood Sugar	110.73	11.07	115.73	10.5	1.795	0.078
HbA1C	7.86	0.83	7.65	0.69	1.051	0.298

Table 2- Comparison of Wound Area (Initial, Final, and Change in Area) Between VAC Dressing and Conventional Dressing Groups

Variable	VAC dressing		Conventional Dressing		Test of significance	
	Mean	SD	Mean	SD	t value	p value
Initial area (mm^2)	53.97	8.8	56.02	8.32	0.925	0.359
Final area (mm^2)	35.2	6.78	48.92	7.98	7.177	<0.001
Change in Area (mm^2)	18.44	3.68	7.08	0.85	16.469	<0.001

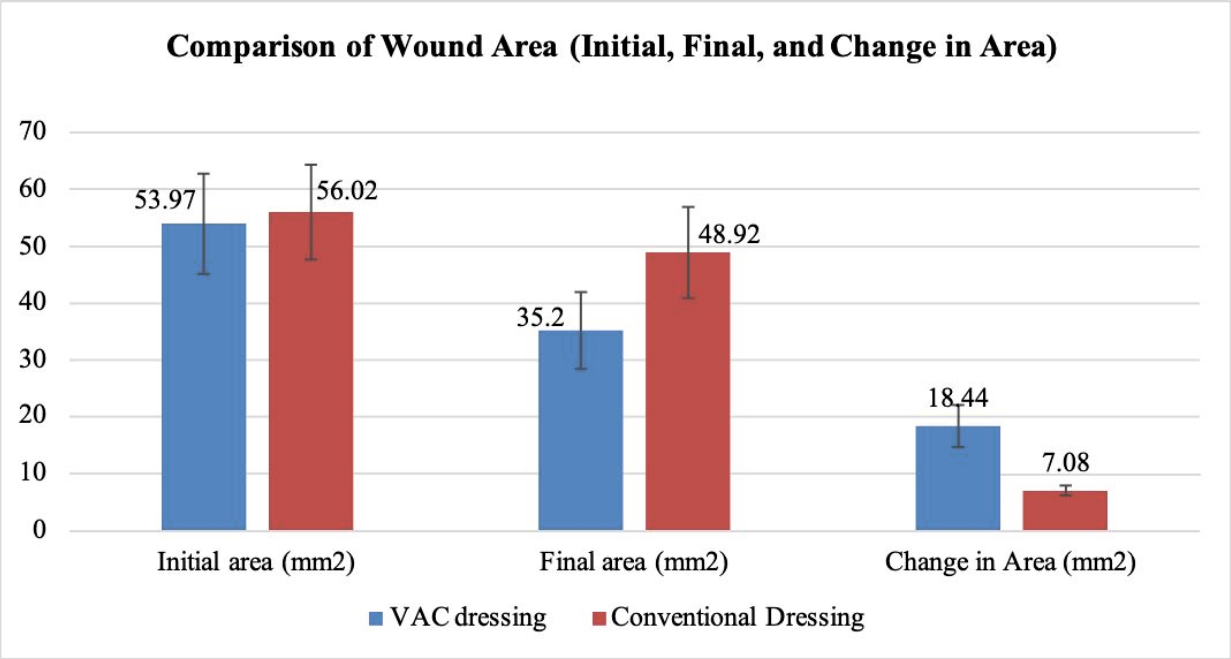

Figure 2: Comparison of Wound Area (Initial, Final, and Change in Area)

Table 3- Comparison of Percentage of Wound Area Reduction Between VAC Dressing and Conventional Dressing Groups

Variable	VAC dressing		Conventional Dressing		Test of significance	
	Mean	SD	Mean	SD	t value	p value
% of Area Reduction	33.8	3.89	12.89	1.89	26.452	<0.001

considerably shorter than the traditional dressing group's 6.14 ± 0.45 weeks.

The two study groups differed statistically significantly, showing that VAC dressings caused wounds to heal more quickly than conventional dressings ($p<0.05$) **(Table 4).**

concluding that VAC dressing was better to conventional dressing in this regard [10]. VAC also is associated with lower length of hospital stays and the incidence of complications [11].

VAC causes increased tissue pressure, which subsequently reduces intravascular hydrostatic pressure (Bernoulli's

Table 4- Comparison of Duration of Wound Contracture (in Weeks) Between VAC Dressing and Conventional Dressing Groups

Variable	VAC dressing		Conventional Dressing		Test of significance	
	Mean	SD	Mean	SD	t value	p value
Duration of Wound Contracture (weeks)	4.47	0.39	6.14	0.45	15.515	<0.001

Discussion

The two groups' initial wound areas were similar in the current investigation. Nonetheless, there was a statistically significant difference in the end wound area between the VAC dressing group and the conventional group. VAC therapy was more successful than traditional dressings at promoting wound healing, as seen by the VAC group's much larger mean reduction in wound area.

Similar findings were reported in a study done in Pakistan, where it was showed that after VAC therapy, the original average wound area of 50.6±27.6 cm^2 decreased to an average size of 11.4±4.55 cm^2 [9]. Additionally, another study observed a noteworthy distinction in the reduction of wound size between diabetic patients treated with VAC dressing and those treated with conventional dressing,

principle) by compressing vessels and increasing intravascular fluid velocity (principle of continuity). Both processes lead to less edema and less intravascular fluid outflow. Furthermore, according to the Venturi principle, higher blood velocity attracts extracellular fluid into the channel. Furthermore, edema is successfully removed from the injured tissues by the compressive forces of negative pressure wound therapy. These routes result in improved cellular oxygenation and decreased interstitial hydrostatic pressure. By immobilizing the wound, VAC therapy speeds up the healing process [12, 13]. These speeds up the healing process by creating the ideal moist environment.

Furthermore, the enhanced diffusion of oxygen and critical nutrients essential for tissue repair due to increased blood flow in the woundbed with Negative Pressure Wound

Therapy (NPWT) offers a dynamic healing process that is continuously involved in wound remodelling with a less total wound load than traditional passive absorption and frequently changing wound dressing. The negative pressure induces mechanical stress at the wound-foam interface, causing cellular deformation with subsequent signalling pathways that promotes angiogenesis and cellular proliferation. In this context, release of growth factors such as, FGF, TGF-beta, VEGF, fibroblast proliferation, a-smooth muscle actin and IL-8, were promoted [14-16]. NPWT play a major role in promoting angiogenesis, increasing blood flow, preventing infection, enhancing the speed of wound closure and increasing growth of granulation tissue in wound [17]. These all imply that VAC treatment improved the decrease in wound size when comparing to standard dressing. VAC provides its superiority due to the peculiar characteristics that it actively leads to wound contraction and granulation tissue by creating a controlled negative pressure environment. With the aid of negative pressure, wound contraction improved and additional fluid and exudate can be removed, therefore decreasing infection and wound maceration. This results from the continuous providing of negative pressure [18, 19]. VAC creates a favorable environment by reducing tissue oedema and bacterial load, thus reducing impediment of the wound bed from granulation tissue formation and wound closure. This combined result leads to an improved decrease in wound size in the VAC group and shows superiority to conventional dressings in the treatment of chronic diabetic wound. Wound area percentage of the VAC dressing group, when comparing to the traditional dressing group, was greater. The difference observed between the two groups was statistically different. Contracture was noted among VAC dressing group on an average of 4.47±0.39 weeks whereas 6.14±0.45 weeks was noted among the traditional dressing group and this difference is statistically significant that shows the fast pace of healing caused by VAC dressings, similar to a trial mentioned previously in which VAC group had an average time for recovery of 21.75±10.55 days [9]. In a comparable study including 60 patients suffering from diabetic foot ulcers showed that VAC therapy group healed in 17.2 days compared to 34.9 days in the traditional dressing group [20]. The result is consistent with findings from other single and multi-center trials [21, 22]. VAC bandages can lead to decreased rates of amputation and autoamputation [23-25]. Application of negative pressure on the wound bed through VAC therapy brings about mechanical micro deformation of the cells. The mechanical stress promotes tissue healing by inducing various biological reactions like growth of fibroblasts and stimulating angiogenesis. The increased blood flow in the woundbed from negative pressure induces growth of granulation tissue. Tissue regeneration and repair necessitate high levels of fibroblast growth factors, i.e., fibroblast growth factor (FGF), transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF), as well as other significant growth factors. VAC Therapy helps to remove fluid collected in interstitial tissues, which lessens tissue swelling and restores the circulation of blood. By so doing, it helps the supply of oxygen and other necessary nutrients in the body required for healing. By removing continuous exudate outflow, bacterial colonization in the wound is reduced, therefore reducing the chances of infection and speeding up the healing process, by maintaining a wound that is clean and moist. It protects the wound from external contaminants and maintains the stable environment of the wound beneficial for quick epithelialization and wound contraction by closing the wound to form a closed environment. Other cytokines released such as IL-8, which can attract cells of the immune system and can promote inflammation, help regenerate tissue and lead to a decreased period of healing.

Strengths and Limitations of the Study

The study has some limitations. A small sample size may hinder the generalisability of the results. The investigation was conducted in a single location which could affect external validity as outcomes may differ in other hospital settings. Additionally, the minimal follow-up period precludes the evaluation of long-term outcomes such as wound recurrence chronic complications or overall limb salvage. Patient adherence and other factors related to patient health such as underlying comorbidities beyond the control of the study design may also have influenced the outcome. Since our study was carried out at a tertiary referral center that specializes in complex diabetic foot ulcers, one of its limitations is the possibility of bias. As a result, the results could not apply entirely to primary care settings or smaller hospitals. Larger, multi-center trials with longer follow-up times should be the main focus of future research to confirm these results and investigate long-term effects including cost- effectiveness and recurrence rates.

According to the study's findings, VAC dressing may be used as a first-line treatment for diabetic wounds, especially when a quicker healing time is crucial. The effectiveness of VAC therapy in improving the wound healing process and lowering the incidence of complications associated with chronic diabetic wounds necessitates the establishment of a standardized set of procedures and recommendations. This standardization is essential to maximize positive patient outcomes and reduce the economic and personal burden posed by these chronic diabetic wounds.

CLINICAL, ETHICAL AND SOCIAL IMPLICATIONS

1. VAC dressing can be considered to have effective clinical benefits in the treatment of diabetic foot ulcers, in those patients needing to achieve quicker healing, a greater percentage reduction in wound area and earlier contraction of the wound when compared with conventional dressings.
2. A shorter healing period for diabetic foot ulcers can result in shorter hospital visits, fewer days lost from work, reduced reliance on and burden of care from caregivers and financial relief to patients and families.
3. Improvements in methods for the management of diabetic foot ulcers might be able to contribute to a reduction in the feelings of social shame, the loss of function and limitations in mobility experienced by many patients with chronic diabetic foot ulcers.
4. This study leads one to conclude that it is important to raise public awareness, increase the number of diabetic patients screened early and promptly referred for further management and increase the availability of wound care in peripheral as well as tertiary care areas.
5. Clinicians should offer evidence-based wound care options while ensuring that patients are informed about the benefits, limitations, cost, availability, and expected outcomes of VAC therapy before treatment selection.

Conclusion

An obvious benefit in accelerating wound healing was shown by the analysis of VAC dressing. In comparison to the traditional dressing group, the VAC dressing group experienced a considerably higher mean and percentage reduction in wound area. In the VAC group, the final wound area was considerably smaller. The VAC dressing promotes quicker wound healing, as seen by the considerably shorter mean time of wound contracture in the VAC group. This demonstrates the shortcomings of traditional dressings in the treatment of complicated diabetic wounds, especially when a smaller wound and quicker healing are essential. Diabetic foot ulcers were successfully treated with the VAC dressing. It accomplishes microbiological clearance and encourages wound bed granulation and wound area reduction.

Declarations

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Artificial intelligence uses declaration statement: No AI tools were used in preparation of the manuscript.

Contributors Statement

Authors GS and SSB contributed substantially to this manuscript in form of conceptualisation, methodology, formal analysis, data curation, investigation, and validation. GS, MS and SSB contributed to literature search, data interpretation, and preparation of original draft & editing. All authors approve of the final manuscript.

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Ethical Approval: The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Institutional Human Ethics Committee of Muzaffarnagar Medical College, Muzaffarnagar, Uttar Pradesh, India No-MMC/IEC/2023/234 dated on 20 March 2023.

Informed Consent Statement: Consent to participate was obtained in writing from all participants included in the study.

Conflict of interest: The authors declare that there are no conflicts of interest.

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