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The Effect of Calcium Alginate Primary Dressing on Diabetic Ulcer Healing in the Proliferative Phase

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ABSTRACT

Diabetes Mellitus (DM) is a global health issue, with diabetic ulcers being a common complication and a high mortality rate. In 2021, around 576 million people worldwide had DM, and this number is projected to reach 643 million by 2030 and 787 million by 2045. The healing process of these ulcers is accelerated in a moist environment and with the use of appropriate primary dressings, such as Calcium Alginate. Objective: The aim is to determine the effect of Calcium Alginate primary dressing on the acceleration of diabetic ulcer healing during the proliferative phase. Methods: This research uses a quantitative study design with a quasi-experimental approach with a control group, employing a pre-test and post-test design. Respondents were divided into two groups: the intervention group and the control group. The intervention group received treatment with calcium alginate, while the control group received treatment with zinc cream. The sample was selected using the consecutive sampling technique. Results: The results of the research indicate a significant difference in the average rate of diabetic ulcer healing between the intervention and control groups. Conclusions: The statistical test was performed using an independent sample T-Test, resulting in a p-value of 0.000 ($p \leq \alpha$ 0.05), indicating a significant effect of the Calcium Alginate primary dressing on the acceleration of diabetic ulcer healing during the proliferative phase, thus supporting its use in enhancing the healing process of diabetic ulcers in this phase

Keywords : Calcium Alginate; Wound Healing; Proliferative

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INTRODUCTION

Diabetes Mellitus (DM) involves persistent dysregulation of blood glucose. This occurs due to the body's inability to produce sufficient insulin (insulin deficiency) or effectively utilize the insulin it produces (insulin resistance) (1). Diabetes mellitus has become a major global health problem, with nearly half a billion people affected worldwide. In 2021, the global prevalence of diabetes mellitus reached approximately 576 million individuals. This figure is projected to rise to 643 million by 2030, further to 787 million by 2045.1 In the same year, Indonesia ranked among the top countries worldwide for the number of adults aged 20–79 years with diabetes, with an estimated 19.5 million individuals. The International Diabetes Federation (IDF) estimates that the number of people with diabetes in Indonesia will increase to 28.6 million by the end of 2024.1 Globally, diabetes caused an estimated 6.7 million deaths in 2021, which is equivalent to one death every five seconds (1).

One of the most serious complications of diabetes mellitus is diabetic foot ulcer, a chronic wound condition that often leads to severe infection, limb amputation, and prolonged hospitalization (2). Ulcers occur in an estimated 15–25% of individuals with diabetes and are considered the leading cause of non-traumatic lower-limb amputation in diabetic patients. Evidence from clinical studies in Indonesia shows that a significant proportion of diabetic foot ulcer patients experience delayed wound healing and increased risk of complications, including amputation. Chronic wounds such as diabetic foot ulcers have profound impacts on patients' quality of life, with substantial physical, psychosocial, and economic burdens (3). These findings highlight the substantial global and local burden posed by diabetic foot ulcers and underscore the urgent need for effective, evidence-based wound care strategies to improve healing outcomes, prevent infection, and reduce the risk of amputation and mortality (4)

Modern wound management has shifted from conventional dry dressings toward the principle of *moist wound healing*, which maintains an optimal moist environment that supports tissue regeneration and accelerates the wound healing process (5). This approach promotes angiogenesis, fibroblast proliferation, and epithelial migration all essential during the proliferative phase of wound healing (6). Experimental and clinical studies report that wounds kept in a moist environment heal faster and more efficiently than wounds left to dry, as moisture enhances cellular activities necessary for tissue repair (7).

Modern moisture-retentive dressings, such as hydrocolloid, hydrogel, and alginate dressings, help maintain this moist environment while providing a protective barrier that may reduce infection risk, prevent external contamination of the wound (8), and minimize tissue trauma during dressing changes when compared with traditional dry gauze dressings (9). Evidence from systematic reviews and clinical studies shows that modern dressings improve overall wound conditions, reduce infection rates, and accelerate healing, particularly in chronic wounds such as diabetic foot ulcers (10).

Despite these advantages, conventional wound care methods are still widely practiced in many clinical settings. Dry dressings may adhere to the wound surface, cause tissue damage upon removal, and fail to provide an environment conducive to cell proliferation and granulation tissue formation, thus

delaying healing (11). Several quasi-experimental and observational studies demonstrate that wounds treated with moist wound healing techniques show reduced necrotic tissue and exudate and faster progression through the proliferative phase compared with conventional methods (12).

This gap in optimal wound management highlights the need for effective, evidence-based dressing approaches to improve healing outcomes and reduce complications such as infection, chronic persistence, and amputation outcomes, particularly critical in patients with diabetic ulcers (12). Research also demonstrates that modern moist wound healing techniques are associated with improved granulation tissue formation, reduced healing time, and better patient quality of life compared with conventional methods (13).

Calcium alginate is a modern wound dressing that maintains a moist environment, which supports fibroblast proliferation and epithelial migration in diabetic ulcers (14). This property helps accelerate the proliferative phase of wound healing (15). Clinical studies report that calcium alginate dressings reduce the risk of infection compared with conventional dry dressings.11 Its flexibility and ability to conform to irregular wound surfaces reduce patient discomfort during dressing changes (3).

In patients with diabetic foot ulcers, calcium alginate has been associated with faster granulation tissue formation and improved overall wound conditions.25 Its ionic properties, such as the release of calcium ions, also promote clotting in exuding wounds, supporting tissue repair(16). When used as part of a structured wound care protocol, it can shorten healing time and optimize outcomes, making it a suitable intervention for evidence-based management of diabetic ulcers. These characteristics directly support the objective of this study to evaluate the effectiveness of calcium alginate in accelerating wound healing in diabetic ulcer patients

METHOD

This research uses a quantitative approach with a quasi-experimental design with a control group, employing a pre-test and post-test format. The study was conducted at Alfacare Center Clinic in Bengkulu from December 6, 2024, to January 6, 2025. Diabetic ulcer care was performed twice a week for four weeks. The independent variable in this study was the use of Calcium Alginate as a primary dressing, while the dependent variable was diabetic ulcer healing. Two groups were involved: the intervention group received Calcium Alginate dressing, and the control group received Zinc Cream dressing. The design did not involve randomization or blinding, and wound care procedures were standardized according to the clinic's protocol to maintain consistency of treatment.

Based on the sample size calculation and subject availability, a total of 61 respondents were recruited using a consecutive sampling technique, with participants assigned to intervention and control groups. The inclusion criteria were patients with diabetic ulcers grade II–III treated at Alfacare Center Clinic, willing to participate as respondents, and diagnosed with diabetes mellitus with diabetic ulcers. The instrument used for data collection was the Bates-Jensen Wound Assessment Tool (BWAT) observation sheet to measure wound healing progress. Data were tabulated and analyzed using the Independent Sample t-test, yielding a p-value of 0.000 ($p \leq 0.05$). This study received ethical approval

from the Health Research Ethics Committee of Poltekkes Kemenkes Bengkulu with ethical clearance number No.KEPK.BKL/657/11/2024.

RESULTS

Table 1 shows that the intervention group had a mean age of 55.90 years (SD = 9.850), a mean blood glucose of 243.06 mg/dL (SD = 82.031), and a DM duration averaging 6.48 years (SD = 3.714). Females made up 54.8%, 48.4% were obese, and 51.6% had light-to-moderate smoking habits. The control group recorded a mean age of 55.10 years (SD = 10.120), a mean blood glucose of 283.35 mg/dL (SD = 88.858), and an average DM duration of 4.90 years (SD = 2.749). Women accounted for 51.6%, 38.7% were obese, and 54.8% reported light-to-heavy smoking.

Table 1. Characteristics of Respondents at Alfacare Center Clinic Bengkulu in 2024 (n=62)

Variable	Group		*P Value*
	Intervention	Control	
Age (years)			
Mean	55.90	55.10	0.752*
Min-max	39-73	40-78	
SD	9.850	10.120	
CI 95%	52.29-59.52	51.38-58.81	
Blood Glucose Level (mg/dL)			
Mean	243.06	283.35	0.069*
Min-Max	117-416	136-427	
SD	82.031	88.858	
CI 95%	212.98-273.15	250.76-315.95	
Duration of DM (years)			
Mean	6.48	4.90	0.062*
Min-Max	1-16	1-10	
SD	3.714	2.749	
CI 95 %	5.12-7.85	3.89-5.91	
Gender			
Male	14 (45.2%)	15(48.4%)	0.799**
Female	17(54.8%)	16(51.6%)	
BMI (kg/m²)			
Underweight (<18.5)	2(6.5%)	3(9.7%)	0.554**
Normal (>18,5-25)	10(32.3%)	8(25.8%)	
Overweight (>25-27)	4(12.9%)	8(25.8%)	
Obesity (>27)	15(48.4%)	12(38.7%)	
Smoking Habit			
Non-smoker	15(48.4%)	14(45.2%)	0.793**
Light smoker	12(38.7%)	12(38.7%)	
Moderate smoker	4(12.9%)	4(12.9%)	
Heavy smoker	0	1(3.2%)	

Independent sample t-test, Chi-square*

Based on Table 2, Scores for all diabetic ulcer characteristics declined in the intervention group. In contrast, the control group experienced an increase in one characteristic after treatment, specifically the wound edge score (from 2.32 to 2.48). This increase was due to the inability of Zinc Cream to effectively manage wound exudate. Excessive exudate can lead to maceration in the surrounding wound area, worsening the condition of the wound edges. Although Zinc Cream has anti-inflammatory properties and supports tissue regeneration, its ability to absorb exudate and create an optimal healing environment is limited compared to Calcium Alginate. During the proliferative phase of wound healing, selecting an appropriate dressing is crucial to supporting the tissue regeneration process.

Table 2 Comparison of Diabetic Ulcer Characteristics Before and After Treatment in Both Study Groups at Alfacare Center Clinic in 2024 (n = 62)

Item	Intervention Group		Control Group	
	Mean (Before)	Mean (After)	Mean (Before)	Mean (After)
Wound Size	3.52	2.13	3.16	2.65
Wound Depth	3.39	1.84	3.65	3.00
Wound Edge	3.16	1.71	2.32	2.48
Tunneling	1.81	1.03	2.16	1.77
Necrotic Tissue Type	2.77	1.23	2.97	2.13
Amount of Necrotic Tissue	2.65	1.16	3.39	1.90
Exudate Type	4.55	3.42	4.65	4.00
Amount of Exudate	3.81	1.90	4.23	3.00
Periwound Skin Color	3.42	1.77	3.26	2.97
Peripheral Edema at Wound Edge	2.45	1.16	2.81	1.94
Peripheral Tissue Induration	1.13	1.03	1.06	1.00
Granulation Tissue	2.97	1.55	3.55	2.29
Epithelialization	4.23	2.23	4.58	3.48

The higher the score, the greater the severity of the wound.

Table 3 Overview of the Acceleration of Diabetic Ulcer Healing Before and After Treatment in Both Study Groups at Alfacare Center Clinic, Bengkulu (n=62)

Variable	Intervention Group		Control Group	
	Before	After	Before	After
BWAT Score				
Mean BWAT	39.83	22.16	41.77	32.61
SD	6.653	5.774	6.535	6.216
CI 95%	37.39-42.27	20.04-24.27	39.37-44.17	30.33-34.89
Min-MAX	27-51	13-35	27-51	15-43

Based on Table 3, the mean score of BWAT before treatment was 39.83 (SD 6.653) in the intervention group and 41.77 (SD 6.535) in the control group. Following treatment, the intervention group's mean score declined to 22.16 (SD = 5.774), in the control group, it was 32.61 (SD 6.216). The data indicate a greater reduction in the intervention group compared to the control group.

Table 4 The difference in the mean score of diabetic ulcer healing acceleration before and after treatment in both study groups at Alfacare Center Clinic in 2024 (n=62)

	Before		After		Mean Difference	CI95%	*P Value*
	Mean	SD	Mean	SD			
BWAT Score							
Intervention (N=31)	39.83	6.653	22.16	5.774	17.67	15.337 s/d 20.017	0.000 *
Control (N=31)	41,77	6.535	32.61	6.216	9.16	7.852 s/d 10.470	0.000 *

* *paired t-test*

Referring to Table 4, the paired t-test results for both groups revealed a p-value of 0.000, which is less than or equal to α (0.05). This indicates a significant difference in the Bates-Jensen Wound Assessment Tool (BWAT) scores before and after treatment in both study groups.

Table 5 The effect of calcium alginate primary dressing on diabetic ulcer healing in proliferative phase

	N	Mean	SD	Mean Difference	*P Value*
Skor BWAT					
Intervensi	31	17.68	6.379	8.516	0.000*
Kontrol	31	9.16	3.569	8.516	

**Independent Sample Test*

Table 5 presents the statistical results of the Independent Sample Test, showing a p-value of 0.000 ≤ α (0.05). This indicates a significant difference in BWAT scores between the intervention and control groups. Therefore, it can be concluded that the use of calcium alginate as a primary dressing significantly accelerates diabetic ulcer healing during the proliferation phase.

DISCUSSION

This research found that more than half of the respondents were female (54.8% in the intervention group and 51.6% in the control group). However, gender differences in diabetic foot ulcer risk are not consistent across studies, and the relationship between sex and ulcer

development remains complex. A meta-analysis reported that male patients with type 2 diabetes have a higher risk of developing diabetic foot ulcers than female patients, suggesting that sex may reflect differences in underlying clinical and behavioral risk profiles rather than serving as a direct causal factor (7). Factors such as peripheral neuropathy, peripheral arterial disease, delayed treatment-seeking behavior, and poorer foot care practices are often more strongly associated with ulcer development than biological sex alone (18). Studies describing the clinical characteristics of diabetic ulcer patients also show that ulcer severity is more closely related to wound condition and comorbid factors than to sex differences (5). Glycemic control has been identified as a major determinant influencing wound healing progression and ulcer severity in patients with diabetic ulcers (6).

In addition, a large prospective and population-based analysis showed that when the severity of established risk factors is comparable, men and women have similar probabilities of developing foot ulceration (19). This finding indicates that sex per se may not independently determine ulcer risk once major clinical risk factors are present. Some regional studies have also reported no statistically significant association between gender and the incidence of diabetic ulcers, further emphasizing that socio-cultural and healthcare access factors may influence observed patterns (20). Therefore, gender distribution in this study should be interpreted descriptively, while acknowledging that diabetic ulcer development is multifactorial and influenced by a combination of metabolic, vascular, neuropathic, and behavioral determinants rather than hormonal status alone.

The results of this research indicate that the average age of respondents in the intervention group was 55.90 years, while in the control group, it was 55.04 years. This may be attributed to the decline in physiological function and the increased risk of angiopathy in individuals over 40 years old. As vascular function deteriorates with age, wound healing becomes more difficult.

More than half of the respondents had been living with DM for ≥5 years. According to Munirah et al. (2024), patients who have had diabetes mellitus for ≥5 years, especially with uncontrolled blood glucose levels, are at higher risk of developing chronic complications such as neuropathy, ischemia, and angiopathy, which can contribute to the development of diabetic ulcers and infections (7). Adherence to medication, adoption of a healthy lifestyle, and regular physical activity are essential components of diabetes management, as they significantly influence patients' quality of life (21). Effective and sustained disease management is therefore crucial to prevent complications, highlighting the importance of personal responsibility in maintaining long-term health among individuals with diabetes mellitus (7).

The mean blood glucose level in this study was ≥200 mg/dL (243.06 mg/dL in the intervention group and 283.35 mg/dL in the control group). According to Nasruddin et al. (2022), individuals with diabetes mellitus (DM) who have a blood glucose level (GDS) of ≥200 mg/dL are nine times more likely to develop diabetic ulcers. Individuals over the age of thirty tend to experience increased blood glucose levels, both in fasting and postprandial states, leading to impaired insulin secretion and resistance at the cellular level. This condition can affect the effectiveness of proteins and other substances essential for diabetic foot ulcer healing(9). High blood glucose levels over a long period can lead to circulatory disorders and reduced sensitivity to stimuli, causing patients to be unaware when they injure their feet(22). Wounds are often only noticed once they have become larger(23). Additionally, poor blood circulation can slow down the wound healing process(24).

Nearly half of the respondents in this study were classified as obese (48.4% vs 38.7%). However, this study did not specifically examine the relationship between obesity and wound healing outcomes, so its effect should be interpreted carefully. Obesity is associated with impaired microcirculation, prolonged inflammation, and metabolic imbalance that may delay the wound healing process. Burgess et al. (2021) also explained that a high body mass index (BMI) can reduce oxygen delivery to tissues and increase oxidative stress in chronic wounds. Therefore, although obesity was common among respondents, further research is needed to determine whether obesity independently affects the healing rate of diabetic ulcers (13).

In this research, smoking habits among respondents showed that in the intervention group, nearly half were classified as light smokers (38.7%), followed by moderate smokers (12.9%). Meanwhile, in the control group, nearly half were also light smokers (38.7%), moderate smokers (12.9%), and heavy smokers (3.2%). The results of this research are consistent with the research conducted by Sastrawan et al. (2023), which found that a history of smoking habits is associated with the occurrence of diabetic ulcer complications ($p = 0.000$). Respondents with diabetes mellitus who smoked were three times more likely to develop diabetic ulcers (14).

The assessment of diabetic ulcer healing acceleration in this research was conducted using the Bates-Jensen Wound Assessment Tool (BWAT). The average wound characteristics in the intervention group showed a significant reduction in scores, indicating improvement. A lower BWAT score corresponds to healthier tissue. The analysis results showed that the mean BWAT score in the intervention group was 39.83 before the intervention and 22.16 after the intervention. Meanwhile, in the control group, the mean BWAT score was 41.77 before the intervention and 32.61 after the intervention.

The findings of this research are consistent with Xie et al. (2022) who reported that calcium alginate can accelerate wound healing due to its hemostatic properties and its ability to support granulation tissue formation, fibroblast proliferation, and collagen synthesis (26). In addition, calcium alginate contains calcium ions that contribute to clot formation and help maintain a stable wound environment, which further supports the healing process (3). These combined effects promote faster tissue repair and improved healing outcomes in chronic wounds.

In this study, wound moisture was maintained using calcium alginate dressings to create an optimal environment for healing and to enhance the effectiveness of the moist wound healing approach. These results are in line with previous findings showing that maintaining a moist wound environment is more effective than conventional dry methods in promoting diabetic ulcer healing (16).

The results of this research reveal a statistically significant difference in the diabetic ulcer healing acceleration scores between the intervention group before and after treatment, as well as between the intervention and control groups. The mean BWAT scores before and after the intervention also differed significantly, with a p-value of 0.000 ($p < 0.05$). Therefore, it can be concluded that there is a statistically significant difference between the two groups.

Statistical tests showed that the use of Calcium Alginate as a primary dressing significantly accelerated diabetic ulcer healing during the proliferation phase ($p < 0.05$). Thus, the alternative hypothesis (H_a) was accepted, indicating that Calcium Alginate contributes to faster wound healing.

However, several limitations should be considered. This study used a quasi-experimental design without randomization or blinding, had a relatively short follow-up period, and could not fully control confounding factors such as glycemic control and infection status. In addition, the sample size was limited to 62 respondents, which may affect the generalizability of the findings. Further studies with larger samples and better control of variables are needed.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, the use of Calcium Alginate primary dressings was associated with faster healing of diabetic ulcers during the proliferative phase at Alfacare Center Clinic, Bengkulu. These results suggest that Calcium Alginate may be a beneficial option for diabetic ulcer care; however, the findings should be considered preliminary due to the study's limitations. Healthcare providers may consider its use as part of wound management, while further studies with larger samples and stronger designs are needed to confirm its effectiveness.

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