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ORIGINAL RESEARCH

The Benefit of Using Apple Cider Vinegar to Reduce Foot Ulcer Grade among Diabetic Patients: A New Dressing Method

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ABSTRACT

Background: In patients with diabetes, diabetic foot ulcers are a significant and frequent consequence that can, in extreme situations, result in the amputation of the lower limbs. This study looked at the impact of a new dressing technique that uses apple cider vinegar on diabetes patients to reduce foot ulcer severity and grade.
Objectives: This study aims to examine the effects of using apple cider vinegar dressing to reduce foot ulcer grade among diabetic patients.
Methodology: A quasi-experimental study conducted at Imam Al-Hassan Center for Endocrinology and Diabetes in holy Kerbala governorate during the period from 26th September 2022 to 12th June 2023.The study sample consist of 60 patients with diabetic foot ulcer were divided into two groups: 30patients were assigned in the intervention group and 30 in the control group. Patients in the intervention group were followed to apply apple cider vinegar dressing, while in the control group only received routine conventional care.
Results: The result indicate that the mean score of diabetic foot ulcer grade of control group is 4.07±0.30 and the mean score of study group is 3.81±0.26. There is a statistically significant difference between pretest and posttest period in healing process and consequently decreasing severity of foot ulcer grades for the study group at p -value (0,00). This study exposed that the using of apple cider vinegar dressing is effective in promoting foot ulcer healing and decrease grades among diabetic patients.
Conclusion: The results of the current study demonstrated that the application of apple cider vinegar dressing reduced the grade severity and enhanced wounds healing of diabetic foot ulcers.

Keywords: Apple Cider Vinegar, Diabetic Foot Ulcers, dressing.

INTRODUCTION

Diabetic foot ulcers are among the most common complications for those with poorly managed diabetes mellitus. The common reasons include inadequate glycemic management, peripheral vascular disease, underlying neuropathy, and poor foot care. Additionally, it frequently leads to lower extremity amputations and foot osteomyelitis where the foot is subjected to pressure and repeated harm

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is where these ulcers generally develop. Every year, between 9.1 and 26.1 million diabetic foot ulcers develop throughout the world. A diabetic foot ulcer will occur in 15 to 25% of patients with diabetes mellitus throughout the course of their lives. As more individuals are diagnosed with diabetes each year, it is anticipated that the occurrence of diabetic foot ulcers would also grow. (Oliver, et al., 2022).

The prevalence of diabetic foot has grown due to the increased frequency of diabetes mellitus worldwide and the extended lifespan of diabetic individuals. Recent research found that diabetes results in the amputation of a lower leg every 30 seconds and that the average yearly cost of treating a diabetic foot is $8659 per patient. In the United States, diabetes involves extra expenditures that vary from $9 to $13 billion for medical treatment related to diabetic foot diseases. The International Diabetes Foundation is educating the general public about diabetic foot problems because of the considerable social, medical, and financial impacts. in diabetes individuals 85% of amputations are brought on by foot ulcerations that develop into severe necrosis or infection. There aren't any research examining this at the moment (Zhang, et al., 2017). Diabetic foot ulceration and amputation were caused by diabetes complications such peripheral vascular disease (PVD) is the reduced circulation of blood to body part other than the brain or heart. In which the vessel of the lower limbs become narrowed. This might lead to poor oxygen circulation and medication delivery, which can impede healing and increase the risk of ulcers. In diabetes, peripheral arterial disease (PAD) is a distinct risk factor for ulceration and limb loss. A potentially growing percentage, 50% of people with diabetic foot ulceration (DFU) have it.14, 15 Patients with DFU and PAD are less likely to recover and are more likely to require an amputation. Consequently, it is imperative that PAD be found in all diabetes patients (Registered Nurses' Association of Ontario, (2013).

Another effect of diabetes that leads to foot ulcers is neuropathy, which can result in loss of feeling, atypical skin, deformities, and reduced joint mobility in the foot. neuropathy occurs when the peripheral nervous system's nerves are compromised (by diabetes). When these neuropathic changes are combined with other elements including poor self-care, insufficient glycemic management, improper footwear, obesity, and a lack of timely assistance, foot ulcers may develop (Bodman, et al., 2022). Additionally, a diabetic person's foot ulcers have a probability of contracting an infection. debridement, antibiotics, and other minor to severe medical interventions for diabetic foot infections include resection and amputation (Lipsky BA, et al., 2015).

Combinations of aerobic and anaerobic bacteria commonly cause the infection of diabetic foot ulcers or chronic sores. The need for new antimicrobial agents has resulted in the resurgence of treatments that have been used for centuries but fell out of favor during the antibiotic era but are safe, widely effective, and have a low propensity to cause resistance. This combination of infections caused the

development of bacterial resistance to antibiotics. debridement involves removing devitalized and contaminated tissue from the wounds in order to show healthy tissue and encourage recovery (Al-Duboni, 2015). Apple vinegar is produced when apple fruits undergo alcoholic or acetic fermentation (AV) (Kara, et al., 2021). numerous studies have shown its effect in controlling blood glucose, anticancer properties, cancer, diabetes, obesity, and other health conditions (Baldas, et al., 2018).

The use of apple vinegar for cleaning and treating nail fungus, head lice, and warts is only one example of how its many antimicrobial properties have clinical therapeutic consequences. Apple vinegar is also well recognized for its effectiveness as a natural preservative for preventing the growth of foodborne pathogenic germs in food or as a surface disinfectant for fruits and vegetables. (Yagnik, et al., 2018). additionally, irrigation of the ear canal with a low vinegar concentration is effective in treating ear infections, otitis, and myringitis (Kara, et al., 2021). Numerous studies have shown that apple vinegar contains significant concentrations of organic acids, phenolic compounds, tannins, flavonoids, and carotenoids, giving it the ability to serve as an antioxidant and an antibacterial against a range of pathogenic agents (Ozturk, et al., 2015).

AIMS OF THE STUDY

This study aims to examine the effects of using apple cider vinegar dressing to reduce foot ulcer grade among diabetic patients.

METHODOLOGY

Research Design: In the current study, a quasi-experimental approach was used. It was done in order to determine how applying an apple cider vinegar dressing improved diabetes patients' wound healing and the severity of their foot ulcers. This study was initiated from 26th September 2022 to 12th June 2023.

Participants: A quasi-experimental study conducted at the Imam Al-Hassan Center for Endocrinology and Diabetes. The study was initiated from September 26, 2022, to June 12, 2023. A non-probability purposive sampling sixty individuals with diabetic foot ulcers were include, the participants were assigned randomly using a simple randomization process into two groups: the intervention group and the control group. Each of the control and intervention groups had 30 participant (Figure 1). Patients in the treatment group were instructed to perform foot ulcer irrigation and apple cider vinegar dressing once a day for 30 days, while only routine care was provided to the control group.

Ethical consideration: This study was approved by the University of Kerbala/Nursing College's Scientific Research Ethical Committee. Each participant provided informed consent to participate in this study. Furthermore, each participant has the opportunity to withdraw from the study at any time..

Materials & measures: In order to gather all information concerning to the study sample, the researchers designed an instrument that has three parts: **First part:** socio-demographic characteristics and clinical data: It is concerned with the patient's socio-demographic data that's include (ages, genders, Marital status, educational level, residency, occupation, smoking status, history of diabetes diagnosis, type of diabetes, type of treatment used, chronic diseases, duration of diabetic foot ulcer disease, ankle-brachial pressure index ratio, and cumulative sugar test (HbA1c). **Second part:** A tool to determine the degree of diabetic foot ulcers designed by Meggitt and Wagner (1976-1979) .This

scale includes six grades that can measure the degree of foot ulcers (from 0 to 5 grades) according to the severity of the ulcer. The degree 0 refer to Intact skin, degree1 refer to Superficial ulcer, degree 2 refer to Ulcer penetrating to tendon or joint capsule, degree 3 refer to Lesion involving deeper tissues, degree 4 refer to Forefoot gangrene, degree 5 refer to Whole foot gangrene involving more than two thirds of the foot. **Third part:** diabetic foot ulcer healing scale. This part uses a DMIST for monitoring the healing of diabetic foot ulcers. It was designed by Oe et al., (2020) and consists of seven domains: depth, maceration, inflammation or infection, size, tissue type of the wound bed, type of wound edge, and tunneling or undermining. This scale was named "DMIST" as an acronym from the initials of these seven domains: if the total points of this scale are from 0 to 11, the healing rate is good; if the total points are from 12 to 23, the healing rate is medium; and if the total points are > 23, the healing rate is weak or late.

Procedure: Patients in the treatment group were instructed to perform foot ulcer irrigation once a day for 30 days, while only routine care was provided to the control group. This intervention its objective is to discover approaches to lessen the severity and speed up the healing process. of DFU by using apple cider vinegar, in this group, every patient received instructions to perform ulcer cleansing with normal saline, irrigation with apple cider vinegar, and dressing. We start by evaluating diabetic foot ulcer healing by using the DMIST scale and classification according to the Meggitt-Wagner classification system for DFU as a pre-test evaluation procedure before the application of the intervention. The ulcer is then cleaned and irrigated with normal saline. After that, the ulcer was irrigated with undiluted (1-5%) apple cider vinegar, and then the wound was cover with sterile gauze soak with apple cider vinegar. Apple cider vinegar was examined to ensure the appropriate concentration for dressing diabetic foot ulcers. The examination process was carried out by an assistant professor of organic chemistry at the College of Nursing, Al-Ameed University, and examined by specialists in the laboratories of the Iraqi Biotechnology Company in Basra Governorate to ensure the toxicity rate on human cells. The results of the examination showed that apple cider vinegar was safe for human cells at this concentration.

The researchers once daily check-ins with the patients if they did not come to the center to ensure the patient perform ulcer cleansing with normal saline, irrigation with apple cider vinegar and dressing. The follow-up method was completed through the phone by establishing communication groups on social media sites (WhatsApp and Telegram) and by communicating with patients through telephones (SIM-card). During this follow-up, the researchers monitored the patient's adherence and responses to the treatment. Patients in the control group just obtain the conventional care provided to all patients in the study setting. The data collection process was carried out from January 12th to April 19th, 2023. The ulcer in both groups was evaluated every week for 30 days to identify the degree of healing.

analysis: The study data were investigated and analyzed using the IBM program Statistical Package of Social Sciences Version 26, using both a descriptive statistical procedure (e.g., frequency, percentage, and mean of score) and a paired sample T-test and an independent sample T-test to compare the mean of the pre-test and post-test scores of nauseas. A p-value of <0.05 was determined to be statistically significant.

RESULTS

The results of table (1) indicates that 66.7% of patients in the control group aged of 40 - 59 years, and 73.3% in study group with mean of age are 49.2 years and standard deviation is 9.73 years. regarding gender of patients, 76.7% and 73.3% are male in control and study group respectively. A 76.7 % of patients are males in two groups as a marital status.

Regarding the clinical data, as shown in table (2) the result exposed that 46.7% of patients in control group with diabetes mellites (DM) for 10- 14 years ago while 43.3% in study group had DM for 15 years and above. A 96.7% and 93.3% of patients in the study and control groups respectively infected with DM type 2. 63.3% of patients in control and study group respectively did not have any chronic diseases other than DM. A 96.7% of patients in control group and 83.3% in study group are newly in diabetic foot (< 4 month ago). Regarding ankle-brachial pressure index ratio, 43.3% and 40.0%of patients in control and study group respectively, had 1.0-1.4mmhg. A76.7% of patients in control group 63.3% of them in study group had reading of HbA1c is (5.7 to 6.4).

It is clear from the results of table (3) indicate that the mean of diabetic foot ulcer grade of control group is (4.07) with a standard deviation of (0.30) and the mean of diabetic foot ulcer grade of study group is (3.81) with a standard deviation of (0.26) with mean difference is (0.25). The result of the t-test (3.53) with a probability value of (0.001) is smaller than the level of significance (0.05). Also, table (4) exposed that there was no difference in diabetic foot ulcer grade readings under the effect of using apple cider vinegar on wounds healing between the periods of the first measure (before application of dressing with using apple cider vinegar) and second measure (one week after application of dressing with using apple cider vinegar), it represents that the mean diabetic foot ulcer grade before applying the interventional protocol was equal than one week after applying it, which can be seen from mean difference (I-J) column. While there was a highly significant difference in diabetic foot ulcer grade readings between the periods of the first measure and third measure (two weeks after application of dressing with using apple cider vinegar) at P-value of 0.00.

The table (5) shows chi-square test results revealed a statistically significant relationship between diabetic foot ulcer grade and educational attainment. All of the single patients had diabetic foot ulcers that were healing at a moderate level, while 78.3% of married patients had excellent diabetic foot ulcer grades, compared to 80% of widowers and 100% of divorcees who had moderate diabetic foot ulcer grades.

DISCUSSION:

The findings of the present study indicate that majority of the participants for each group (study and control) are aged of 40 - 59 years. The study also showed that most of the study sample are male in both control and study group. These findings come with agreement of these of Eltokhy, et al., (2016). They conducted an interventional study to evaluate vinegar simple method in dressing of pseudomonas infected wound at Faculty of Medicine, Al-Azhar University in Egypt. Their sample's gender was male more than female. The finding of present study showed that Two thirds of patients are married male in both groups.

A third of the control group participants have elementary school certification and near a half of the study group respondents have elementary school certification too. Participants in both control and study groups live in urban areas. A quiet half of patients in control group are laborers and about a half of patients in study group as well as. A little below the half of patients in both groups do not smoke. Through the assessment of the participants' clinical information, it was revealed that about a half of patients in the control group had infected with diabetes mellitus for whom with 10- 14 years before, while those in the study group had diabetes mellitus in the last 15 years and above for a semi ratio. High ratios of patients in both control and study group have respectively infected with diabetes mellitus type II.

According to these findings, more than half of patients in the control group and fewer than half of those in the trial group received insulin as their primary form of therapy for diabetes mellitus. Except for diabetes mellitus, the majority of the patients in the control and study groups, respectively, did not

have any other chronic illnesses. In both the control and research groups, a large percentage of patients had a diabetic foot less than four months prior. Nearly 50% of patients in the control and study groups had an ankle-brachial pressure index ratio of 1.0-1.4mmhg. HbA1c ranges of (5.7 to 6.4) were present in over two thirds of patients in the control group and over fifty percent of those in the research group. The study's findings, according to the researcher, demonstrated a convergence in proportions between the data from the research sample and the control group. The study's findings make it evident that the mean rate of healing diabetic foot ulcers in the study group is greater than the rate of healing diabetic foot ulcers in the control group. Those findings are supported with these of Al-Duboni, et al., (2015) study. In Iraq, they carried out an interventional trial to evaluate the effectiveness of vinegar treatment on bacterial development when treating diabetic foot ulcers. They came to the conclusion that vinegar therapy was related with decreased bacterial growth and was more successful and efficient at debriding non-healing foot and leg ulcers in diabetes patients than ongoing standard care.

It is clear from the results that the mean of diabetic foot ulcers grade within study group is higher than the mean of diabetic foot ulcers grade within control group. Also, the t-test value for the diabetic foot ulcers grade with a high probability value of (0.000). This interprets the high effect of apple cider vinegar on grade of diabetic foot ulcer and wounds healing that was applied on within the study group patients. rates. A study by Allawi, et al., (2019) is conducted to investigate effect of apple cider vinegar on the healing of experimentally–induced wounds infected with Pseudomonas aeruginosa at College of Veterinary Medicine, University of Mosul, Mosul, Iraq. They revealed that using amounts of apple cider vinegar and the lead to more rapid and better healing of the diabetic infected ulcer wounds.

Additionally, there was no difference in the diabetic foot ulcer grade readings under the effect of using apple cider vinegar on wound healing between the periods of the first measure (prior to the application of a dressing containing apple cider vinegar) and the second measure (one week after the application of a dressing containing apple cider vinegar), but there was a highly significant difference between the periods of the first measure and third measurement. Makhdoom, et al., (2009) conducted an experimental study design to evaluate management of diabetic foot by natural honey in Jamshoro, Pakistan. They concluded that natural honey caused decreasing the rate of leg or foot amputations and enhancing the healing process.

There was a highly significant difference in the grade of diabetic foot ulcers between the first measure and the fourth measure (three weeks after application of dressing with apple cider vinegar), with a P-value of 0.000, indicating that the mean diabetic foot ulcer grade before applying the interventional protocol was higher than three weeks after applying it. At Hospital University Sains Malaysia, Shukrimi et al. (2008) conducted a control-controlled trial research to examine the effectiveness of honey and povidone iodine as dressing solutions treating Wagner type II diabetic foot ulcers. They discovered that applying honey to wounds can help manage diabetic foot ulcers, speed up wound healing, and more effectively reduce edema and odor.

According to the researcher, the healing process was affected by the application of apple cider vinegar to wounds over the course of four measurement periods, with the fourth measurement period being much better than the first. Our results back up the advantages of vinegar treatment that have been asserted by earlier writers such as Dissemond et al. (2003). They documented the successful debridement of non-healing wounds in 22 diabetes patients over the course of two weeks with an average of six vinegar treatments; 12 wounds were healed in just one week. Similar findings were made by Leung et al. (2001) and Bowler et al. (2001) about the effectiveness of vinegar therapy in the

debridement of diabetic foot sores. The effects on wound closure were not examined, claimed outcomes were arbitrary, and there were no control groups. There have only ever been two trials on vinegar treatment with control groups.

CONCLUSION:

In conclusion, the apple cider vinegar dressing is an effected for treat and consequently reduce the grade of diabetic foot ulcer. The study indicates that there is a statistically differences between study and control groups.

RECOMMENDATION:

Based on the findings of the present study, the following recommendation were made:

1. Apple cider vinegar dressing is indicated as a diabetic foot dressing for patients with chronic diabetic foot ulcers.
2. Further and future research efforts on larger sample size are needed for the evaluation of efficacy of apple cider vinegar for its regular use in the diabetic foot care products to determine its effect on the healing level and grade of diabetic foot ulcer especially on the healing process.

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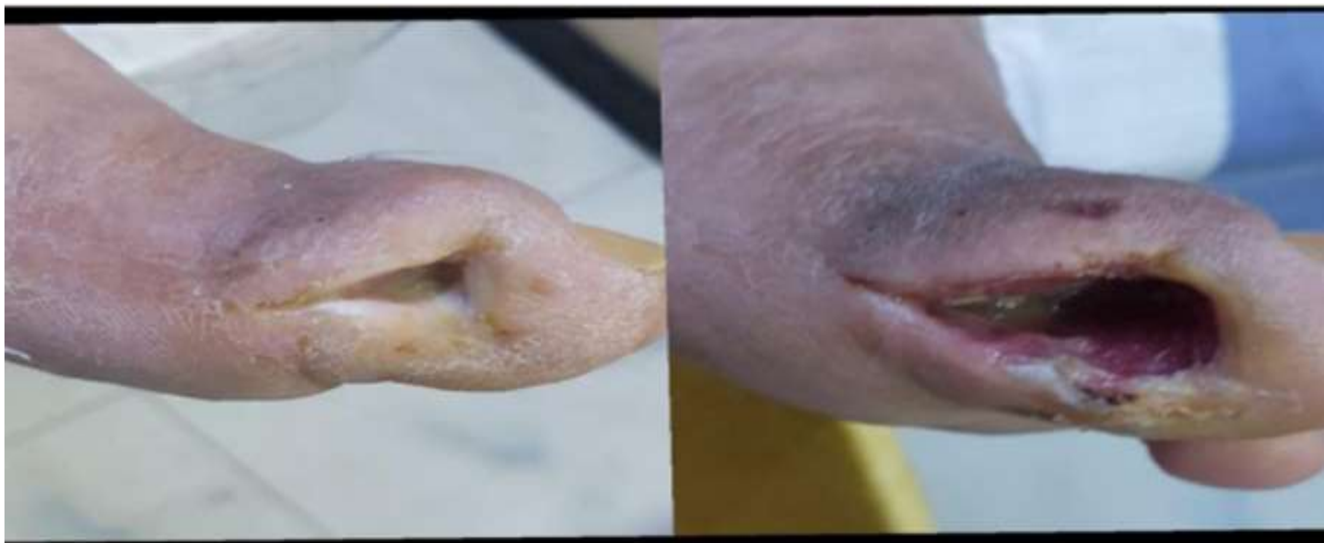
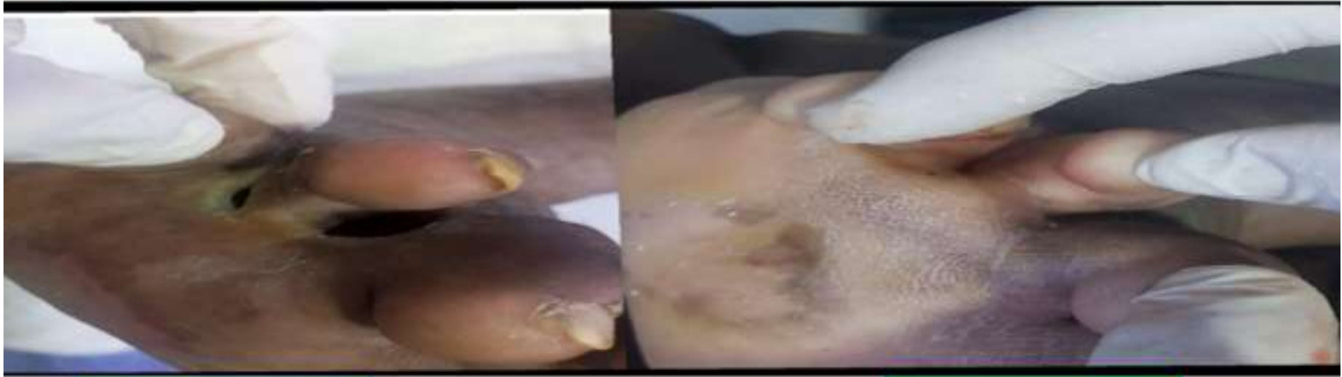
FIGURES & TABLES

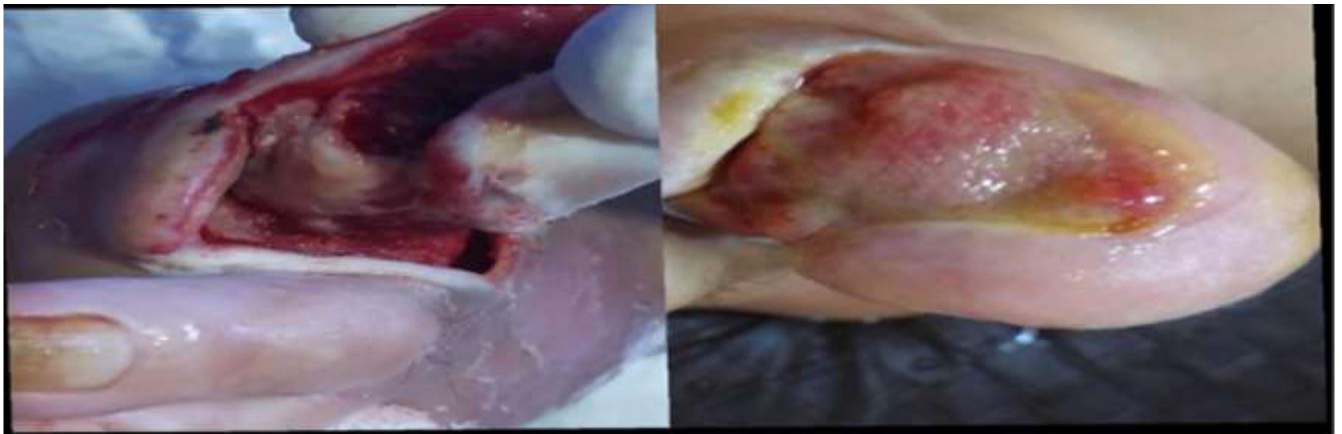


Before

After



Before After



Before After

Before After

Pictures of Patients Before and After Applications of Interventional Protocols (Apple cider vinegar dressing).

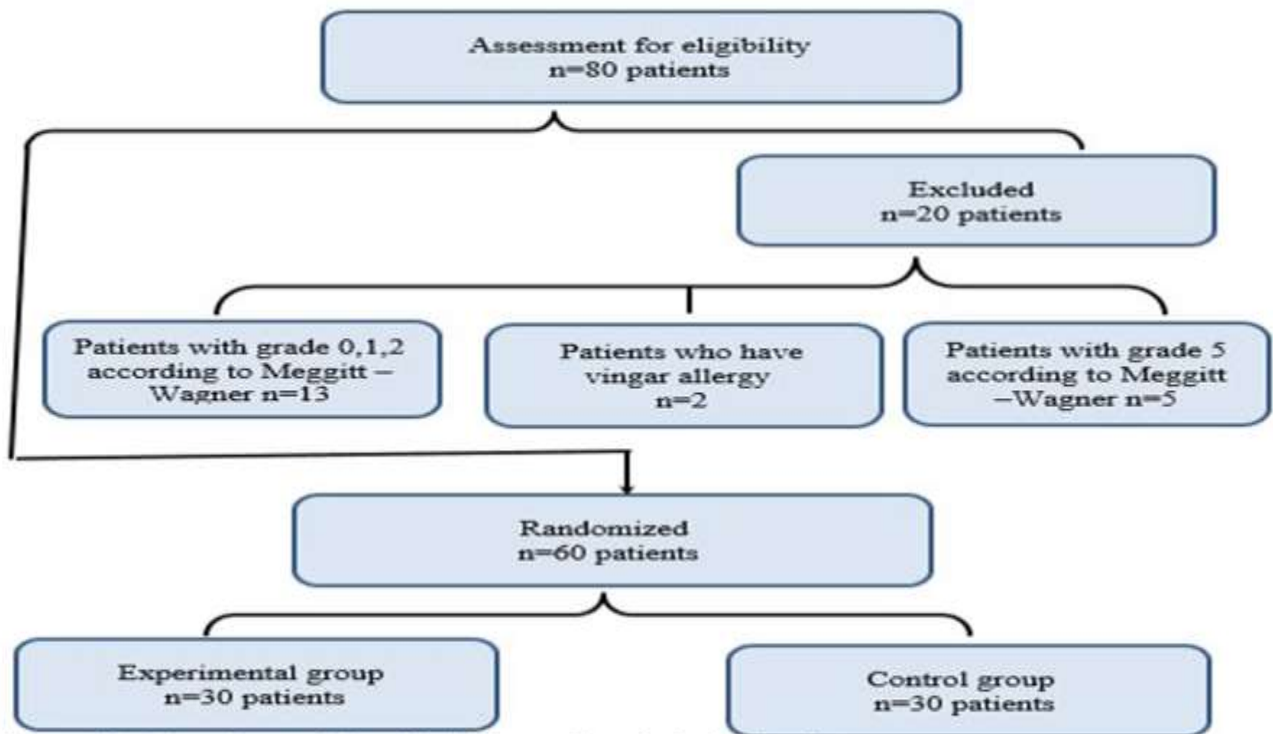


Figure (1): Flowchart of the eligibility and excluded criteria.

Table (1): Distribution of participants according to their socio- demographic characteristics

Socio-demographic characteristics		Control group n=30		Study group n=30		p- value
		F	%	F	%	
Age groups	20-39 years	6	20.0	3	10.0	0.354
	40 - 59 years	20	66.7	22	73.3	
	≥ 60 years	4	13.3	5	16.7	
	M±SD				49.2±9.73	
Gender	Male	23	76.7	22	73.3	0.770
	Female	7	23.3	8	26.7	
Marital status	Single	2	6.7	1	3.3	0.647
	Married	23	76.7	23	76.7	
	Widower	4	13.3	5	16.7	
	Divorced	1	3.3	1	3.3	
Educational level	Does not read or write	5	16.7	3	10.0	0.680
	Reads and writes	6	20.0	4	13.3	
	Elementary school	10	33.3	13	43.3	
	Middle school	6	20.0	9	30.0	
	Preparatory school	2	6.7	1	3.3	
	Collage or above	1	3.3	3	10.0	
Residence	Urban	26	86.7	26	86.7	1.00
	Rural	4	13.3	4	13.3	

f. (frequency); % (percentage).

Table (2): Distribution of participants according to their clinical data

Clinical data		Control group n=30		Study group n=30		P- Value
		F	%	F	%	
Duration of infected with DM	**<5 years**	0	0	3	10.0	0.050
	5-9 years	9	30.0	6	20.0	
	10- 14 years	14	46.7	8	26.7	
	15 years and above	7	23.3	13	43.3	
Type of DM	**Type 1**	1	3.3	2	6.7	
	Type 2	29	96.7	28	93.3	0.802
Type of treatment used	**Diet**	0	0	2	6.7	1.00
	Hypoglycemic tablets	14	46.7	14	46.7	
	Insulin	16	53.3	16	53.3	
Chronic diseases	**Heart disease**	7	23.3	9	30.0	0.266
	kidney failure	1	3.3	2	6.7	
	None	22	73.3	19	63.3	
Duration of diabetic foot	**< 4 months**	29	96.7	25	83.3	0.048
	4-6 months	1	3.3	3	10.0	
	≥7 month	0	0	2	6.7	
Ankle-brachial pressure index ratio	**> 1.4**	0	0	1	3.3	0.072
	1.0-1.4	13	43.3	12	40.0	
	0.9-1.0	8	26.7	7	23.3	
	0.8-0.9	7	23.3	5	16.7	
	0.5-0.8	1	3.3	5	16.7	
	< 0.5	1	3.3	0	0	
HbA1c	**< 5.7**	1	3.3	0	0	0.066
	5.7 to 6.4	23	76.7	19	63.3	
	≥ 6.5	6	20.0	11	36.7	

f. (frequency); % (percentage)

Table (3): The difference between the mean of diabetic foot ulcer grade results of the Control and Study group

Variables		N	Mean	Std. Deviation	Mean Difference	T	Sig.
diabetic foot ulcer grade	**Control group**	30	4.0750	.30193	.25833	3.539	.001
	Study group	30	3.8167	.26207			

Table (4): Pairwise comparisons of diabetic foot ulcer grade readings under the effect of using apple cider vinegar on wounds grade between the four measurements periods among the study group

(I) time	(J) time	Mean Difference (I-J)	Std. Error	p-value	Sig.
1	**2**	.000	.000	--	**--**
	3	.310	.087	.001	HS
	4	.724	.084	.000	**HS**
2	**1**	.000	.000	--	**--**
	3	.310	.087	.001	HS

	4	.724	.084	.000	**HS**
3	**1**	-.310	.087	.001	HS
	2	-.310	.087	.001	HS
	4	.414	.093	.000	**HS**
4	**1**	-.724	.084	.000	**HS**
	2	-.724	.084	.000	**HS**
	3	-.414	.093	.000	**HS**

*Based on estimated marginal means the mean difference is significant at the 0.05 level. NS: Non-Significant (P value >0.05); S: Significant (P value ≤0.05- > 0.01); HS: Highly Significant (P value ≤0.01). (I) time = The measurement to which it is compared. (J) time = Measurements that compare to the main measurement.

Table (5): Association between patients' diabetic foot ulcer grade with their demographic characteristics posttest

Socio-demographic characteristics		**diabetic foot ulcer grade**						**X^2**		
		Intact skin	**Superficial ulcer**	**Ulcer penetrating to tendon or joint capsule**	**Lesion involving deeper tissues**	**Forefoot gangrene**	**Whole foot gangrene involving more than two thirds of the foot**	**X^2-value**	**p-value**	**Sig.**
Age	**20-39 years**	0	0	33.3	66.7	0	0	**7,06**	**.315**	**NS**
	40 - 59 years	0	0	68.2	31.8	0	0			
	≥ 60 years	0	0	60	40	0	0			
Gender	**Male**	0	0	54.5	45.5	0	0	**3,2353**	**.357**	**NS**
	Female	0	0	87.5	12.5	0	0			
Marital status	**Single**	0	0	0	100	0	0	**8.000**	**.534**	**NS**
	Married	0	0	69.5	30.5	0	0			
	Widower	0	0	60	40	0	0			
	Divorced	0	0	0	100	0	0			
Educational level	**Does not read or write**	0	0	66.7	33.3	0	0	**9.85**	**.048**	**S**
	Reads and writes	0	0	75	25	0	0			
	Elementary school	0	0	61.6	38.4	0	0			
	Middle school	0	0	66.7	33.3	0	0			
	Preparatory school	0	0	61.6	38.4	0	0			
	Collage or above	0	0	0	100	0	0			
Residence	**Urban**	0	0	61.6	38.4	0	0	**21.23**	**.050**	**S**
	Rural	0	0	75	25	0	0			
	No	0	0	64.3	35.7	0	0			
	Previously	0	0	63.3	36.7	0	0			

Sig.: significance, S: significance, NS: non significance, X2: chi-square