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Effect of silver colloid dressing over conventional dressings in diabetic foot ulcer: A prospective study

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ABSTRACT

Objective: Topical silver treatments and silver dressings are increasingly being utilized for the local treatment of wounds; nevertheless, the evidence for their usefulness is unclear. The aim of this study was to investigate the impact of conventional dressings and silver colloid dressing on diabetic foot ulcers (DFU) with and without compression therapy.

Material and Methods: This prospective, double-blind experiment included 50 patients with non-ischemic DFUs, split into two groups of 25 patients each. The study was conducted for a period of six months. The primary endpoint was to evaluate the entire epithelialization (total healing) of all ulcers on the study leg.

Results: The ulcer area significantly decreased in the colloidal silver group (67.77 ± 17.82%) compared to the conventional saline group (21.70 ± 23.52%). When compared to the conventional group, the colloidal silver group required considerably fewer days to reach the endpoint (23.15 ± 8.15 days vs. 48.35 ± 18.07 days), and by day 14, ulcer area reduction (from 100%) was greater (48% in the silver group vs. 89.69% in the conventional group).

Conclusion: In managing DFUs, unstructured hydrogel wound dressings using silver colloids based on ionic silver are more effective than regular saline dressings since they heal wounds more quickly in fewer days while also drastically reducing ulcer areas over time.

Keywords: Diabetic foot ulcer, silver colloid dressing, bandaging, dressing therapy

INTRODUCTION

A diabetic foot ulcer (DFU) refers to a chronic, non-healing wound or sore that occurs on the leg or foot of an individual with diabetes. DFUs are frequently observed as a complication of diabetes, especially in those with inadequate blood glucose management or long-standing diabetes. Diabetic foot ulcers (Figure 1,2) can develop due to a combination of factors, including peripheral neuropathy (nerve damage), peripheral arterial disease (reduced blood flow), impaired wound healing, and due to increased susceptibility to infection (1).

An ulcer is defined as a break in the continuity of the covering epithelium. Foot ulcers can occur in both acute and chronic forms, and they can be attributed to various factors such as venous or arterial insufficiency, diabetes, burns, trauma, chronic pressure, or surgical interventions. The use of antiseptic agents may reduce the bacterial load but it may simultaneously hamper the fibroblast and other viable tissues (2).

Many forms of dressing are available including hydrocolloid dressings, foam dressings, paraffin dressings, and polyurethane dressings. Hydrocolloid dressings are a type of wound dressing that can be used for various types of wounds, including those in diabetic legs. These dressings are made of a gel-like material that contains hydro active particles, such as gelatine or sodium carboxy-methyl cellulose, which absorb wound exudates (fluid) and create a moist environment for the wound. Foam dressings are designed to absorb exudates from the wound while maintaining a cozy environment. They are made of soft, flexible materials that contain small open cells. The dressings have a non-adherent outer layer that helps prevent sticking to the wound bed. Paraffin dressings, also known as paraffin gauze dressings, are a type of wound dressing that consists of fine mesh gauze impregnated with paraffin wax. Paraffin dressings are commonly used in the

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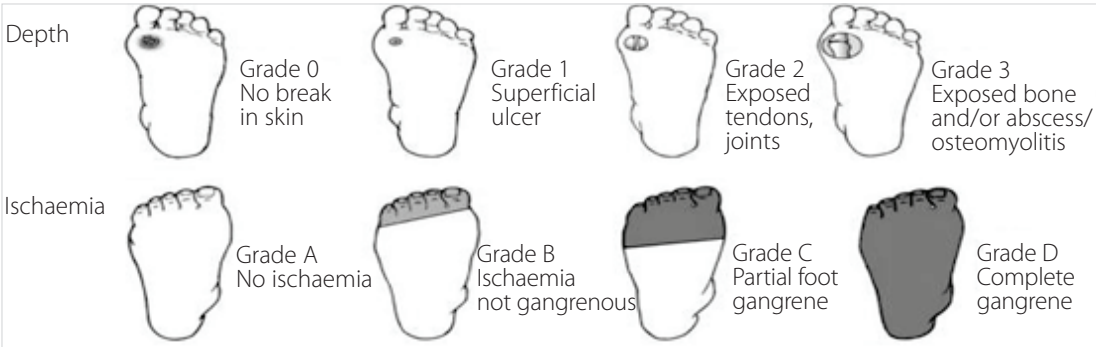


Figure 1. Diabetic foot ulcers-foot & ankle-orthobullets.

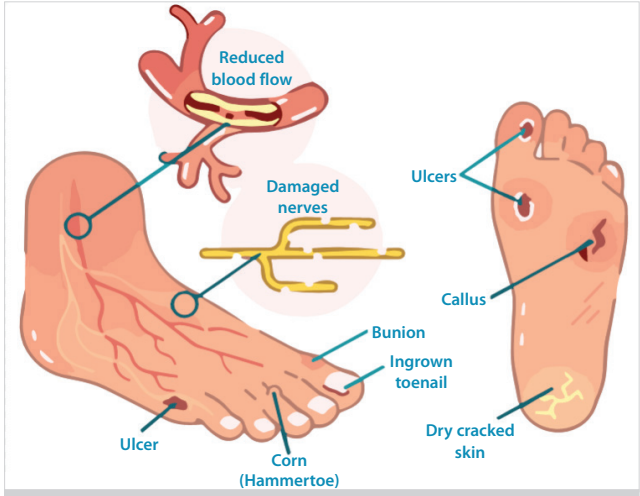


Figure 2. Diabetic foot.

management of burns, particularly superficial burns, and can also be used for other types of wounds. Polyurethane dressings are a type of wound dressing that is commonly used in the management of various types of wounds. These dressings are made of a thin, flexible, and transparent film or foam that is composed of polyurethane (3-6).

Beginning around 1000 BC, the Greeks and Romans utilized silver as a cleanser, antibiotic, and therapy for illnesses (7). Even though silver has a very low potential for toxin formation and only very rarely leads to microbial resistance, in vitro studies have demonstrated the effectiveness of silver-based dressings in battling pathogenic germs. So, the use of silver colloid in diabetic and venous ulcers acts as a very effective tool in wound management. With the increasing surface area to volume ratios accompanied by decreased toxicity to the tissues, the advent of nanotechnology has enabled the development of nano-silver particles that has a huge role in accelerated wound healing (8,9) (Figure 3,4).

The study aimed to assess and compare silver colloidal dressings with conventional dressings for the treatment of DFUs.

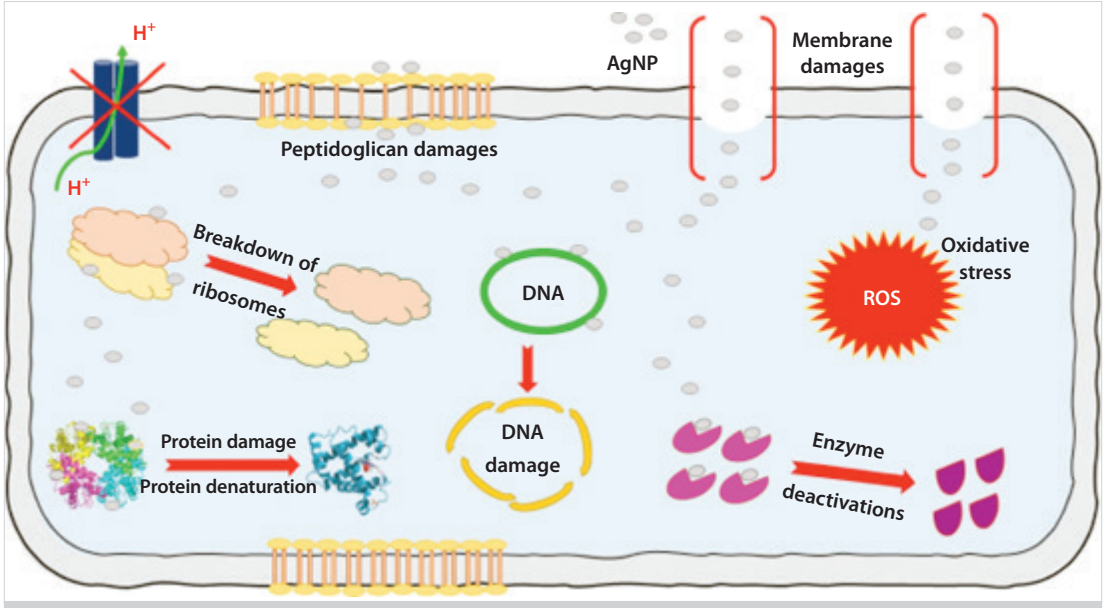


Figure 3. Silver-and silver nanoparticle-containing wound dressings for wound healing.

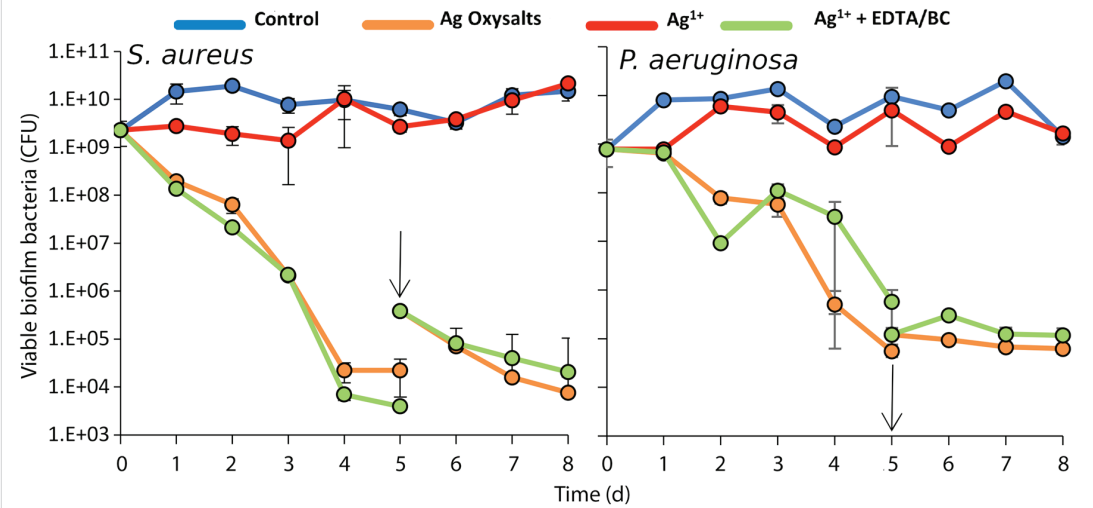


Figure 4. Silver oxynitrate-based dressings' anti-biofilm properties and facilitation of healing.

MATERIAL and METHODS

The study involved a total of 50 patients who had provided their consent to participate. It was a prospective study conducted at the Department of General Surgery in Indira Gandhi Institute of Medical Sciences Hospital. The study was conducted for a period of six months and was approved by the Institution Ethics Committee.

Simple random sampling was employed for the individuals in the study. Fifty patients were divided equally into two groups, group A and group B, with 25 patients in each group. The first 25 patients received conventional wound dressing as per standard practice, belonging to group A. The next 25 patients received silver colloid dressing, belonging to group B. The purpose of this division was to compare the outcomes of the two different dressing methods.

The patients were followed up for a period of six months to assess the effectiveness of the respective dressings. Data was collected and analysed to evaluate factors such as wound healing, infection control, and overall management of DFUs. This study design helped provide valuable insights into the potential benefits of silver colloid dressing compared to conventional dressing for DFUs.

Patient Criteria

The study included all adult patients who had a DFU with an area of at least 2 cm^2. These ulcers fell under Wagner grades I and II, indicating relatively superficial ulcers with no significant infection or tissue involvement. The ulcers had a minimum duration of 30 days, indicating chronic wounds that had not led within a reasonable timeframe. Specific criteria were used to exclude certain patients from participating in the study. These exclusion criteria were as follows - 1) patients with foot ulcers caused by other underlying conditions such as paraplegia, varicose veins, or other coexisting diseases, 2) patients with conditions or factors such as vasculitis, carcinoma, immune system disorders, treatment with corticosteroids, connective tissue disease, chemotherapy, immune suppressive agents, radiation therapy, uncontrolled diabetes, or osteomyelitis that can prevent a wound from healing, 3) patients known to have hypersensitivity or allergic reactions to colloidal silver gel, the substance being studied, 4) patients who had tested positive for COVID-19, indicating an active infection and patients who had tested positive for specific antibodies (seropositive), indicating a previous COVID-19 infection.

Statistical Analysis

Chi-square test was employed in the statistical analysis of the gathered data. The software used for data analysis was SPSS version 1.0.0.1406. The statistical program helped analyse and interpret the data obtained from the study, providing valuable insights into the effectiveness of the compared treatment methods.

RESULTS

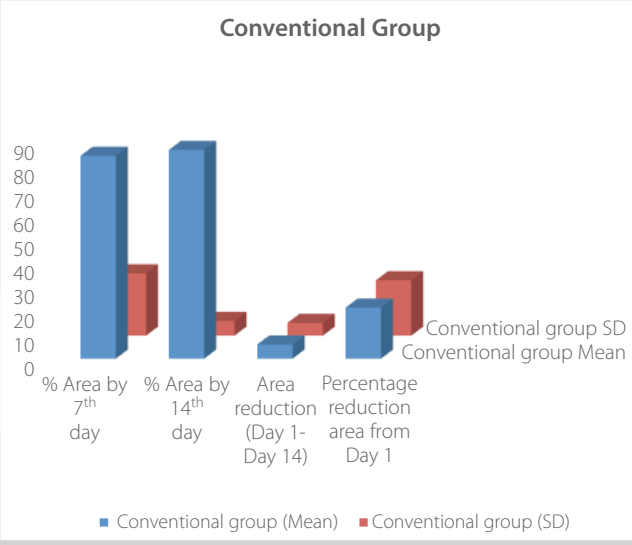
In the study, participants' average ages ranged from 57.6 years for group A to 62.4 years for group B. Although no particular numbers were given, both groups had a higher proportion of male patients (Table 1). The division of ulcers according to their cause (spontaneous or post-traumatic) was compared between group A and group B. While considering the number of dressings needed, the average for group B was 11.5, which was much less than the average of group A which was found to be 24.04, and this difference was found to be statistically significant ($p< 0.05$).

In group A, 40% of the participants required repeated dressings, which indicates that a substantial portion of this group needed dressings multiple times during the study period. While

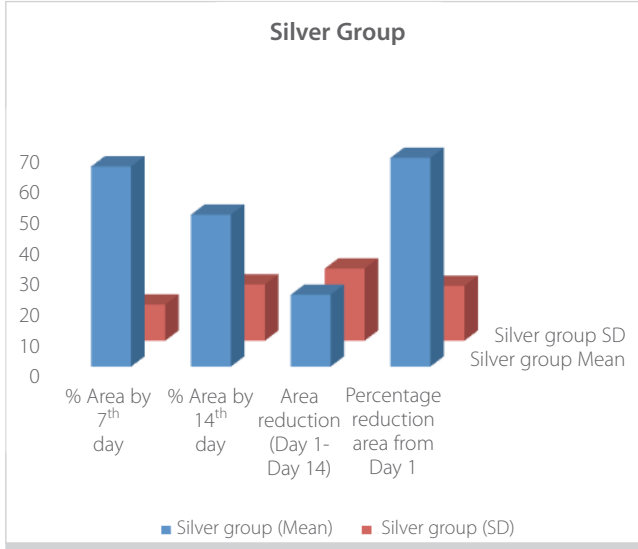
Table 1. The quantity of dressings needed in each group

	Silver group		Conventional group	
Number	Count	Column n %	Count	Column n %
1.0	25	100%	15	60%
2.0	0	.0%	5	20%
3.0	0	.0%	4	16%
5.0	0	.0%	1	4%
p= 0.02, Chi-square test				
	Mean	SD	Mean	SD
Area by 7th day, %	65.00	11.78	86.19	26.47
Area by 14th day, %	49.34	18.29	88.68	6.28
Area reduction (day 1-day 14)	23.34	23.46	6.05	5.48
Percentage reduction area from day 1	67.77	17.82	21.70	23.52

comparing group B to group A, significant reductions in ulcer areas were observed. Group B showed reductions of 65% ± 11.78% on day seven, 86.19 ± 26.47% on day seven, and 49.34 ± 18.29% on day 14 compared to group A. These reductions indicate that the ulcers in group B decreased in size more rapidly compared to group A. By day 14, when compared to group A, the mean area reduction in group B was a little larger. The ulcer area reduced to 23.34 ± 23.46 cm^2 in group B, while in group A, it reduced to 6.05 ± 5.48 cm^2. The difference in mean area reduction was found to be statistically significant ($p< 0.05$). The study also reported that the percentage reduction in ulcer area was higher in group B (67.77 ± 17.82%) compared to group A (21.70 ± 23.52%). These percentages indicate the relative reduction in ulcer area compared to the initial size (Graphic 1,2).



Graphic 1. Silver group.



Graphic 2. Conventional group.

Furthermore, when compared to group A, the total days to reach the study's endpoint were significantly lower in group B. Group B reached the endpoint in an average of 23.15 ± 8.15 days, while group A took an average of 48.35 ± 18.07 days. This difference in the time taken to reach the endpoint was found to be statistically significant, although the specific statistical test used was not mentioned.

DISCUSSION

Diabetes has many complications, one of which is DFUs, which can have serious consequences if not properly managed. They typically occur as a result of reduced blood flow, nerve damage, and impaired wound healing associated with diabetes. Nearly 70% of patients with DFUs require surgical procedures, and 40% of the patients end up needing a cutaway (5,7,10). Given the high occurrence of DFUs, which impose a substantial

burden of morbidity on individuals with diabetes and the extensive understanding of the disease process in diabetic patients, the inquiry arises as to whether the current standard of care for DFUs, which involves conventional dressings, should be re-evaluated in light of the various modern biological dressings that are now accessible (10-13).

Alluvial silver acts as ions of the silver depot and has a sustained local antibacterial effect, as well as sufficient water for the absorption of excess exudates, avoidance of microbial settlement, and relatively painless bandage removal, and all contribute to the creation of this environment. Ionic silver ions have been created as the active component in alluvial silver-based dressings as a result of nanotechnology's use of silver's wound-healing abilities. These bioactive dressings have been successfully developed and are now widely available in various countries. By harnessing the potential of nanotechnology, these dressings offer enhanced wound healing capabilities and have emerged as a valuable tool in promoting effective wound management. It is believed to have broad-spectrum antimicrobial activity, which means it can potentially help in reducing the risk of infection in diabetic foot ulcers (14-16).

As per our study, various criteria have been practiced while the effectiveness of traditional dressings and ionic silver-based dressings for DFU therapy. According to the study on day seven, the ulcer in the colloidal silver dressing group was significantly reduced to 65% (compared to the initial area of 100%) and the colloid silver dressing group's area of the ulcer was dramatically reduced to 49.34% by day 14 (compared to the conventional dressing's 88.68%). The colloidal silver dressing group had a considerably shorter duration reaching the endpoint, which was endogenous closure or an ulcer suitable for parted weight skin grafting when compared to the conventional dressing group.

Compared to more traditional topical silver treatments (Figure 5), colloidal silver dressing has essentially no or very little systemic toxicity. There is some evidence suggesting that colloidal silver may have anti-inflammatory properties and can promote wound healing by reducing inflammation and stimulating tissue repair (17). This is because smaller particles have more surface area and elute silver ions from the body at a rate that is far lower than what is necessary to cause systemic poisoning. According to studies, a topical adjuvant used in wound care is frequently ineffective against microbe-produced biofilms, which are generally resistant to removal with silver (18,19).

Preparations based on silver particles serve as a reservoir for silver ions, ensuring long-term maintenance of the ideal silver ion concentration. This sustained and optimal concentration allows for the delivery of silver ions, which possess anti-biofilm properties, at levels exceeding 30 ppm while avoiding systemic effects by staying below 60 ppm. By achieving this balance, the use of colloidal silver-based preparations promotes the desired therapeutic effects without causing harm to the body. As a result, the ultimate purpose of each dressing is to produce an environment that is favourable for wound healing.

Studies have demonstrated the efficacy of silver against microbial biofilms, which are typically resistant to standard wound care treatments. By acting as a depot for silver ions, colloidal silver-based dressings maintain an optimal concentration of silver ions, creating a favourable environment for wound healing (11). It is important to note that the choice between colloidal silver dressings and conventional dressings for DFU should be made based on individual patient factors, wound characteristics, and healthcare professionals' recommendations. The goal is to select the most appropriate dressing that optimizes wound healing, reduces the risk of infection, and addresses specific patient needs.

Currently, the most frequent kind of long-lasting, on-healing foot ulcers found in clinical practices have not generally acknowledged the standard of care for treatment. These ulcers pose a significant burden of morbidity among diabetic

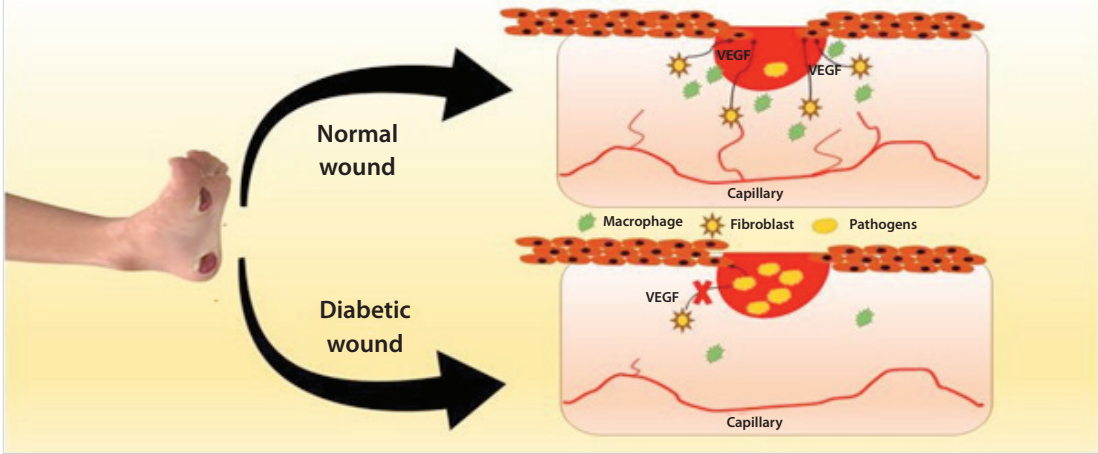


Figure 5. Advanced and promising technology for treating diabetic wounds is silver nanoparticles.

patients, with approximately 40% of patients eventually requiring amputation and 70% of patients requiring surgical intervention (20).

Given the prevalence and severity of DFUs, it is essential to evaluate whether conventional dressings are still reasonable as the standard of care, especially considering the availability of modern biological dressings. Despite being a well-known adjunct in wound healing, the use of silver has primarily been focused on burn wounds rather than DFUs. However, advancements in nanotechnology have led to the development of these based dressings with ionic ions as the present ingredient, which has shown promise in wound healing (11,20).

The study of Sharma et al., has demonstrated a noteworthy reduction in the ulcer in the area in the colloidal silver dressing group, with a reduction of 66% (compared to the initial area of 100%) on day seven. In comparison, the conventional dressing group has shown a reduction of 85.18% on day seven. Furthermore, on day 14, the colloidal silver dressing group has exhibited a significant reduction to 48% of the initial ulcer area, while the conventional dressing group has shown a reduction to 89.69%. The size of the wound decreased at a faster rate in silver colloid dressing than in conventional diabetic foot dressing (5).

According to Gupta V et al., dressings with nanocrystalline silver ions have emerged as an economical option for managing diabetic foot ulcers. These dressings contain tiny silver particles that release silver ions, which have antimicrobial properties. By using nanocrystalline silver dressings, the period of hospitalization for patients with diabetic foot ulcers can be reduced, resulting in a decreased burden on the healthcare system. Antimicrobial properties of nanocrystalline silver ions help prevent and treat infections in diabetic foot ulcers, which can lead to faster healing and improved outcomes for patients. Additionally, by reducing the need for prolonged hospital stays, nanocrystalline silver ion dressings can help to optimize healthcare resources and reduce healthcare costs. The cost-effectiveness of nanocrystalline silver ion dressings lies in their ability to promote wound healing and prevent complications, which can ultimately reduce the overall treatment costs associated with ulcers in diabetic feet. By reducing the healing time and minimizing the risk of infections, these dressings can potentially lead to shorter hospital stays, fewer healthcare visits, and lower expenses for patients and the healthcare system as a whole. Overall, the utilization of nanocrystalline silver ion dressings in the treatment of diabetic foot ulcers offers a cost-effective approach that not only improves patient outcomes but also eases the burden on healthcare resources (10).

Additionally, the final objective, which could be a suitable ulcer for split-thickness skin grafting or spontaneous closure, was reached by the colloidal silver dressing group much more quickly than the standard dressing group. The colloidal silver group also required fewer dressings overall until reaching the endpoint. Although the length of hospitalization did not show a statistically significant difference, it is worth noting that this factor may be influenced by various patient-related factors and is not the sole determinant of the dressing material's efficacy (12).

Ionic dressings are more effective than traditional dressings for healing these foot ulcers, according to the results of our study. These dressings promote faster wound healing, require fewer dressings overall, and provide a conducive environment for wound recovery. Ionic silver-based dressings should be strongly explored for implementation as the level of treatment for treating this ulcer due to its cost-effectiveness and improved results (21). As a result, we infer from our research that ionic silver-based dressings are unquestionably a superior method of treating DFUs and also a financially viable option for patients. As a result, we strongly advise that their adoption as the standard of care for the management of diabetic foot ulcers be strongly considered.

It is important to note that without specific details about the study, such as the study design, sample size, methodology, and any potential limitations, it is difficult to assess the overall quality and generalizability of the findings.

CONCLUSION

Silver-based dressings have a faster rate of wound healing. This was shown by the granulation tissue's early development, the treatment's effectiveness after two weeks, a decline in the percentage of slough and discharge, and a real reduction in the percentage of ulcer area. Additionally, the patients in our trial group who received ionic silver-based dressings reached the end point sooner and either had an ulcer that had spontaneously closed or was ready for a split-thickness skin graft. Also, patients in the colloidal silver group required significantly fewer dressings overall compared to the patients in the conventional group.

Ethics Committee Approval: This study was approved by the Indira Gandhi Institute (Decision no: 495/IEC/IGIMS/2022, Date: 01.04.2022).

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - AR, VB; Design - YT; Supervision - VB; Fundings - VB, YT; Materials - AR, SS; Data Collection and/or Processing - AR, YT; Analysis and/or Interpretation - SS; Literature Search - AR; Writing Manuscript - AR; Critical Reviews - SS, AR.

Conflict of Interest: The authors have no conflicts of interest to declare.

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ORİJİNAL ÇALIŞMA-ÖZET
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Diyabetik ayak ülserinde gümüş kolloid pansumanın geleneksel pansumanlar karşısında etkisi: Prospektif bir çalışma

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ÖZET

Giriş ve Amaç: Topikal gümüş tedavileri ve gümüş pansumanlar yaraların lokal tedavisi için giderek daha fazla kullanılmaktadır ancak bunların yararlılığına ilişkin kanıtlar net değildir. Bu çalışmada, kompresyon tedavisi uygulanan ve uygulanmayan diyabetik ayak ülserleri (DFU) üzerinde geleneksel pansumanların ve gümüş kolloid pansumanın etkisi araştırılmıştır.

Gereç ve Yöntem: Bu prospektif, çift kör deney, her biri 25 hastadan oluşan iki gruba ayrılmış, iskemik olmayan DFU'lu 50 hastayı içermektedir. Çalışma altı aylık bir süre boyunca yürütülmüştür. Birincil sonlanım noktası, çalışma bacağındaki tüm ülserlerin tüm epitelizasyonunu (toplam iyileşme) değerlendirmekti.

Bulgular: Ülser alanı kolloidal gümüş grubunda (%67,77 ± 17,82) konvansiyonel serum fizyolojik grubuna (%21,70 ± 23,52) kıyasla önemli ölçüde azalmıştır. Geleneksel grupla karşılaştırıldığında, kolloidal gümüş grubunun son noktaya ulaşması için önemli ölçüde daha az gün gerekmiştir (23,15 ± 8,15 güne karşılık 48,35 ± 18,07 gün) ve 14. günde ülser alanındaki küçülme (%100'den geriye) daha fazla olmuştur (gümüş grubunda %48'e karşı geleneksel grupta %89,69).

Sonuç: DFU'ların yönetiminde, iyonik gümüş bazlı gümüş kolloidler kullanan yapılandırılmamış hidrojel yara örtüleri, yaraları daha az günde daha hızlı iyileştirdiği ve zaman içinde ülser alanlarını önemli ölçüde azalttığı için normal serum fizyolojik içeren yara örtülerinden daha etkilidir.

Anahtar Kelimeler: Diyabetik ayak ülseri, gümüş kolloid pansuman, bandajlama, pansuman tedavisi

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