The Egyptian Journal of Hospital Medicine (January 2025) Vol. 98, Page 304- 310

Efficacy Versus Cost of Different Types of Silver Dressings on Healing of Neuropathic Diabetic Foot Ulcers

Aya Mohamed Elbialy, Mohamed Roshdi Abdel Ghani, Fady Kyrillos
Internal Medicine Department, Unit of Diabetes & Endocrinology, Faculty of Medicine, Mansoura University, Egypt
Corresponding author: Aya Mohamed Elbialy, **Tel:** 01006192716, **Email:** Aya.ali@mans.edu.eg

ABSTRACT

Background: Wound care is essential in diabetic foot ulcers (DFUs) management. Different silver dressings are available at varied prices, but there is no agreement on which is the most cost-effective for DFU healing.

Objective: This study aimed to explore the cost efficacy of existing silver dressings in healing of neuropathic DFU.

Patients and methods: The study was a prospective, randomized, single center comparative, which included 60 patients with neuropathic DFUs. All patients received standard wound management. They were randomly distinct into two groups based on the type of dressing used: silver foam treatment (Mepilex® Ag) or nanocrystalline silver spray (Silver Sol®). Target was the percentage of ulcer surface area reduction after 12 weeks or complete healing.

Results: Sociodemographic data and ulcer characteristics were comparable in both groups. Initial median ulcer surface area was 2.33 cm^2 (0.25-5) vs. 3.0 cm^2 (0.72-6.0) in foam and spray groups respectively (**p=0.127).** After 12 weeks, the reduction of ulcer surface area was higher among foam group (43.9 % vs. 20.3 %) (**p=0.049)**. Complete ulcer healing was considerably higher in the foam group, 66.7 % vs. 36.7% in spray group (**p = 0.02)**. The mean total cost of dressings per patient was considerably lower in Mepilex® group (368.0 ± 121.78 LE) than in Silver Sol® group (950.0 ± 0.0 LE) (**p <0.001)**.

Conclusions: Silver ions foam dressing is significantly more cost effective than nanocrystalline silver spray in healing of neuropathic DFUs.

Keywords: Silver ions, Silver nanoparticles, Diabetic foot ulcer.

INTRODUCTION

The risk of foot ulcer is 15%-20% in subjects with diabetes. The main cause of nontraumatic lower limb amputation is diabetes. Amputation is often preceded by a foot ulcer [1]. Diabetic Foot Ulcers (DFUs) are complex chronic wounds, with a high influence on morbidity and mortality [2].

DFUs are characterized by prolonged healing time due to lack of normal repair to get healing within a specified time [3]. Wound care including debridement, wound bed preparation, and recent technologies that alter the physiology of wound to enable healing, are most important for DFU healing [4].

The traditional concept believes that keeping the wound surface dry with sufficient delivered oxygen increases wound healing. Recently, more practitioners realized that wounds heal more rapidly in a wet environment rather than in a dry one [5]. New dressings that help with the wet environment have widely replaced the traditional ones. Silver ion dressings, hydrogel dressings, foam dressings, and honey dressings are nowadays the most used in clinical practice [6].

In the early 1800s, silver leaf and wire of silver suture were used during wartime to treat acute wounds and avoid infection [7]. The utilization of silver in wound management dates to 1970s, with the introduction of silver sulphadiazine, providing an effective antimicrobial agent [8].

The effectiveness of silver ions derived from dissolved silver sulphate or silver sulfadiazine against bacteria has already been demonstrated. Along with ionic silver, silver nanoparticles have also gained attraction as antimicrobial agents with the development of nanotechnology. Ionic silver refers to silver in its ionic form, which carries a positive charge (Ag^+). Nano-silver, on the other hand, consists of extremely small silver particles, ranging from 1 to 100 nm and having a neutral electric charge [9, 10].

Strong bactericidal and bacteriostatic properties are exhibited by silver ions. Under both aerobic and anaerobic conditions, it can kill a diversity of microorganisms, including bacteria, viruses, fungi, and protozoa, by blocking their respiratory chain, damaging their cell membrane, and combining their RNA and DNA to prevent normal replication, transcription, and translation [9].

Because of their high surface area to volume ratio and capacity to continuously release silver ions, silver nanoparticles also exhibit potent antibacterial action [10]. Apart from its antibacterial properties, prior research has demonstrated that silver dressings can facilitate wound healing by influencing fibroblast and keratinocyte migration and regulating cell differentiation [11, 12].

When combined with proven components of gold-standard multidisciplinary treatment, therapies aimed at improving wound healing must be sufficiently backed by high quality evidence demonstrating their efficacy and cost effectiveness due to the growing expenses of managing DFU [4].

The Egyptian market offers a variety of silver dressing formulas at varying price points, but there is little consensus on which one is better for DFU healing.

Received: 11/08/2024
Accepted: 09/10/2024

Therefore, this study aimed to assess and compare the efficacy of two types of silver dressings on healing of neuropathic DFUs and evaluate their cost effectiveness.

PATIENTS AND METHODS

Study was a prospective, randomized, single center, comparative which included 60 patients with neuropathic DFUs. The study was conducted at Diabetic Foot Clinic in Specialized Medical Hospital, Mansoura University, Egypt. These ulcers fell under Texas 1A or 2A, indicating relatively superficial ulcers with no ischemia or infection [13]. The ulcers minimum duration was 15 days, indicating chronicity with no healing within an acceptable time.

Exclusion criteria: Anemia (Hb < 10 gm/dl), ischemic heart disease, heart failure, hepatic or renal impairment (serum creatinine > 1.5 mg/dl), HbA1c > 8, and inability to use the offloading devices.

Baseline sociodemographic data, and details on diabetes-related clinical issues (such as duration, diabetes medications, and glycated hemoglobin values) were documented at the initial visit. The ankle brachial index of the foot affected was measured to evaluate peripheral vascular circulation.

All patients were subjected to sharp wound debridement and suitable offloading devices. Simple random sampling was employed, and 60 patients were divided equally into two groups. The first 30 patients received silver foam dressing (Mepilex® Ag foam) that costs 240 Egyptian pounds per 10×10 cm sheet. Mepilex Ag foam is an absorbent polyurethane foam dressing (impregnated with silver sulphate ($AgSO_4$) salts, 1 mg/cm^2) with Safetac silicon wound contact layer.

The next 30 patients received nanocrystalline silver spray (Silver sol® solution) that costs 950 Egyptian pounds per 236 ml bottle. In both groups, changing the dressing was every 1-3 days, according to the level of soaking of the absorbent dressing. During the first visit, patients received guidance concerning the appropriate dressing change at home. Follow up visits were every 2 weeks with measurement of ulcers surface area till complete healing or end of study at 12 weeks.

The primary endpoint was the reduction in wound size by calculating ulcers surface area every 2 weeks. Mayrovitz formula was used to calculate the ulcers surface area using (A [area] = L [length] × W [width] × 0.785) [14]

Proportion of wound healed =100 x Initial wound area (cm^2) - wound area after treatment (cm^2) / Initial wound area (cm^2)

The rate of complete ulcer healing was the secondary endpoint.

Ethical Approval: All procedures were following the ethical standards of the 1964 Helsinki Declaration. Mansoura Faculty of Medicine Ethics Committee granted ethical approval. Code number: R21.02.1227. All participants included in the study gave their informed consents.

Statistical analysis

The software used for data analysis was SPSS version (26). Descriptive data were conveyed as percentages for categorical variables. Continuous variables were recorded as the mean ± SD or median and range, depending on whether the data were normally or non-normally distributed. Student's t-test and Mann Whitney U test were used for continuous variables and Chi-squared test, Fisher exact test or Monte Carlo test for categorical variables. A p-value less than 0.05 was considered significant.

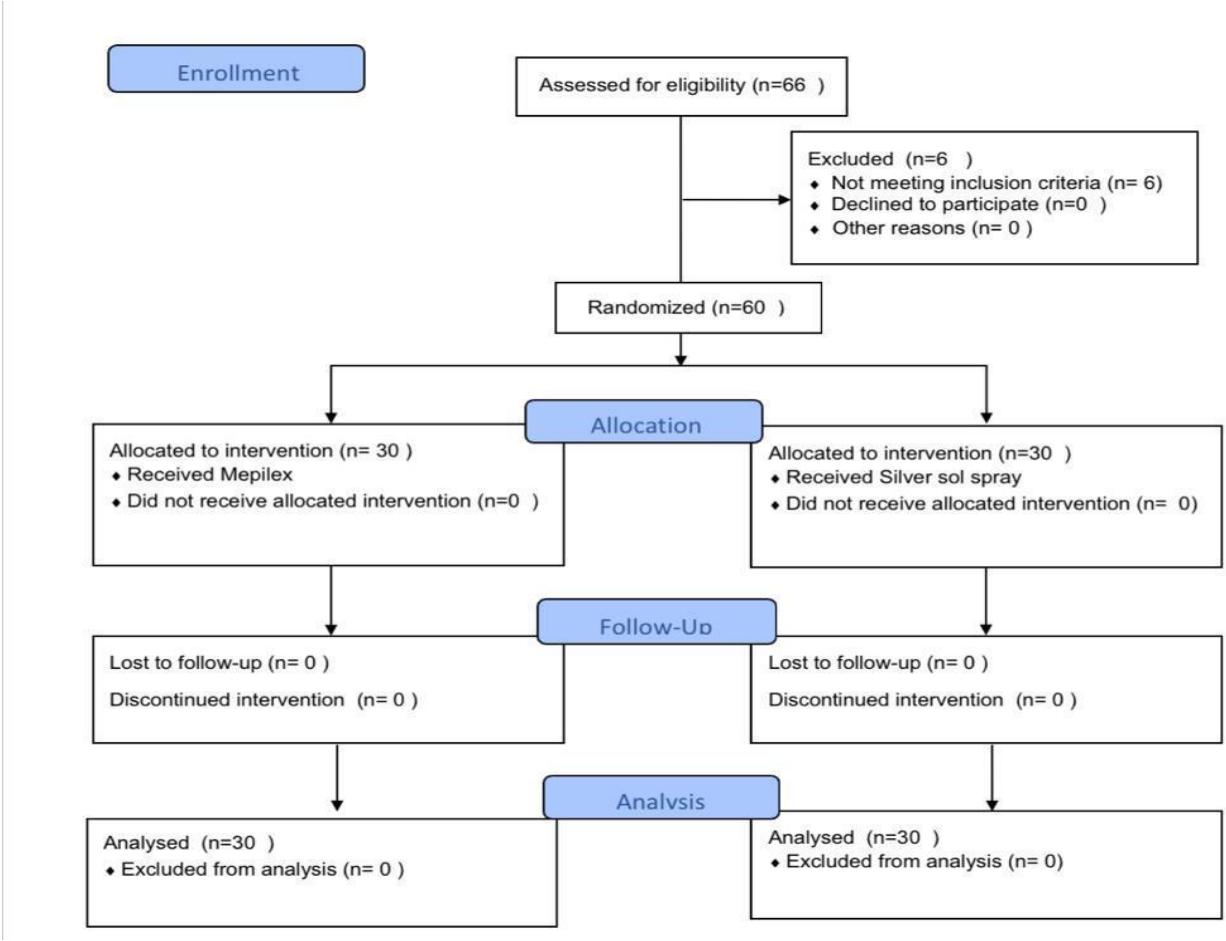

Figure (1): CONSORT Flow chart showing study design

RESULTS

The mean age in silver foam group was 56.27 years, and in nanocrystalline silver spray group was 54.5 years. The baseline sociodemographic data were comparable in both groups (Table 1).

Table (1): Sociodemographic characteristics among studied groups

	Silver foam group (N = 30)	Nanocrystalline silver spray group (N = 30)	test of significance
Age/years. Mean ± SD	56.27±8.96	54.50±9.63	t=0.736 p= 0.465
Gender: Male	13(43.3)	18(60)	χ^2=1.67
Female	17(56.7)	12(40)	p= 0.196
Occupation			
• No	21(70)	11(36.7)	MC=7.33
• Manual worker	6(20)	14(46.7)	p= 0.062
• Employee	1(3.3)	3(10)	
• Retired	2(6.7)	2(6.7)	
Residence: Urban	11(36.7)	9(30)	χ^2=0.300
Rural	19(63.3)	21(70)	p=0.584
Marital status: Married	29 (96.7)	30(100)	FET=1.02
Widow	1(3.3)	0	P= 1.0
Body mass index (kg/m^2)	33.46±2.87	33.41±3.23	t=0.066, p= 0.948
Smoking	3(10)	5(16.7)	χ^2=0.577, p= 0.448

Parameters are described as number (percentage) or median (min-max). MC: Monte Carlo test, χ^2= Chi-Square test, FET: Fischer exact test.

No statistically significant difference was found between both groups regarding type, duration, and medications of diabetes or other comorbidities (Table 2).

Table (2): Comparison of diabetic characteristics and comorbidities among studied groups

	Silver foam group (N= 30)	Nanocrystalline silver spray group (N= 30)	test of significance
Type of DM T1D T2D	 1(3.3) 29(96.7)	 4(13.3) 26(86.7)	χ^{2FET}=1.96 p= 0.161
Diabetes duration (years)	15(4-45)	14(4-24)	z=1.49 p= 0.137
Antidiabetic medications Oral Insulin	 1(3.3) 29(96.7)	 0 30(100)	χ^{2FET} =1.02 p= 1.0
Medications for Stroke Hypertension No chronic medications	 2(6.7) 10(33.3) 18(60)	 0 9(30) 21(70)	MC=2.28 p= 0.319

Parameters are described as number (percentage) or median (min-max). MC: Monte Carlo test., FET: Fischer exact test, Z: Mann Whitney U test.

DFU characteristics were not significantly different among both groups (Table 3).

Table (3): Comparison of ulcer characteristics among studied groups

	Silver foam group N= 30	Nanocrystalline silver spray group (N= 30)	test of significance
Foot affected Right Left	 18(60) 12(40)	 23(76.7) 7(23.3)	χ^2=1.93 p=0.165
Ulcer location Metatarsal heads Midfoot Heel Dorsum Hallux	 12(40) 4(13.3) 2(6.7) 1(3.3) 11(36.7)	 8(26.7) 3(10) 4(13.3) 1(3.3) 14(46.7)	MC=1.97 p= 0.741
Ulcer duration (months)	1 month (2 weeks-24 months)	1 month (2 weeks -24 months)	z=0.541 p= 0.589

MC: Monte Carlo test, Z: Mann Whitney U test. Parameters described as median (min-max), or as number (percentage).

Initial mean ulcers surface area was comparable among both groups. Table (4) showed the changes that occurred on ulcers surface area while using the 2 different studied dressings, during the follow-up period.

Table (4): Comparison of ulcer surface area among studied groups

Ulcers Surface area (cm^2)	Silver foam group	Nanocrystalline silver spray group	test of significance
Pre	2.33(0.25-5)	3.0(0.72-6.0)	z=1.53 p= 0.127
After 1 month	0.875(0.4-5)	2.6(0.5-5.77)	z=1.71 p= 0.09
After 2 months	1(0.25-2.56)	2.56(1-5.6)	z=2.64 **p= 0.008***
After 3 months	0.75(0.25-2.88)	2(0.25-5.8)	z=1.87 p = 0.062

Z: Mann Whitney U test., *statistically significant. Parameters are described as median (min-max)

Silver foam dressing showed a statistically significant reduction of ulcers surface area versus nanocrystalline silver spray after 2 months **(p = 0.038)**, and after 3 months **(p = 0.049)** of follow up period (Table 5).

Table (5): Improvement of ulcers surface area among studied groups during the follow up period

% of reduction of ulcers surface area	Silver foam group N= 30	Nanocrystalline silver spray group N= 30	test of significance
Pre/ After 1 month	21.6%	13.9%	p= 0.42
Pre/ After 2 months	36.4%	13.3%	**p= 0.038***
Pre/ After 3 months	43.9%	20.3%	**p= 0.049***

Z test: Mann Whitney U test., *statistically significant

Silver foam group showed a significantly higher rate of complete ulcer healing at 12 weeks (20 (66.7%) vs 11 (36.7%), respectively, **p = 0.02**). The timing of complete ulcer healing among both groups was shown in table (6). The mean total cost of dressings per patient was significantly lower in Mepilex® group (368.0 ± 121.78 Egyptian pounds) than in Silver Sol® group (950.0±0.0 Egyptian pounds), **p<0.001**.

Table (6): Cases with complete ulcer healing among studied groups

Time of assessment	Silver foam group N=20(%)	Nanocrystalline silver spray group N=11(%)	test of significance
After 1 month	5(50%)	5(50%)	$\chi 2$=0.0 p=1.0
After 2 months	6(60%)	4(40%)	$\chi 2$=0.48 p=0.488
After 3 months	9(81.8%)	2(18.2%)	$\chi 2$=5.45 **p=0.01***

χ^2=Chi-Square test, *statistically significant.

DISCUSSION

The efficacy of silver on wound healing has long been debatable. In 2010, a systematic review issued in Cochrane Library showed that there was not enough data to say whether silver dressings helped speed up ulcer healing or prevent infections [15]**.** Newer research results showed that silver ions can kill the wound bacteria and improve wound healing [16, 17]**.** A meta-analysis (including 31 randomized controlled trials (RCTs) and 8 cohort studies) published in 2017 reported that silver, beside its antimicrobial effects, is cost effective and can improve the quality of patients' life. They emphasized that silver's use in wound care is far superior to what was acknowledged in the scientific debates [18]. Another meta-analysis published in 2022, including 7 RCTs, demonstrated that silver dressings enhance DFU healing rate, reduce in-hospital duration, improve infection, but with no significant effect on reduction of ulcer area [19]**.**

The limited number of patients in some studies (which may lead to problems with randomization and insufficient research power) and the variety of inclusion criteria, study methods, and endpoints employed make it difficult to assess and compare studies. Therefore, it should come as no surprise that some meta-analyses and systematic reviews have reached different results or have not found enough comparable evidence. The efficacy and safety of silver dressings differs from one type to another. It depends on the type of silver used, total silver content, and material utilized. The cost effectiveness of silver dressings is a complex multifactorial issue, however research has linked them to elements that lower costs, such as reduced healing times, reduced dressings change frequency and shorter hospital stays [20].

Our study aimed to assess and compare the efficacy of two different silver dressings, silver foam dressing (Mepilex® Ag foam) and nanocrystalline silver spray (Silver sol® solution), on healing of neuropathic non-infected non-ischemic DFUs and evaluate its cost effectiveness. Our study revealed that silver foam was superior in wound size reduction than that of nanocrystalline silver spray after 2 months (**p= 0.038**), and 3 months (**p= 0.049**) of follow up treatment period. At 12 weeks, the rate of complete ulcer healing in silver foam group was statistically higher than in nanocrystalline silver spray group (20 (66.7%) vs 11 (36.7%) respectively, **p= 0.02**).

Revelli *et al.* [21] compare the antimicrobial efficacy of silver nanoparticles, in the form of Silver Sol solution, versus 5 antibiotics (macrolides, penicillins, cephalosporins, quinolones and tetracyclines). The study

was conducted in vitro on prepared bacterial cultures. They reported that Silver Sol had a broad- antimicrobial spectrum than other used antibiotics.

Multiple studies have applied different silver modern dressings to the treatment of DFUs. **Zhang and Xing** [22] compared the efficacy of Mepilex foam versus Vaseline Gauze in DFU management. They reported that Mepilex group was significantly more effective regarding the mean healing time. **Jude *et al.*** [23] studied the efficacy of Aquacel Ag (silver Hydrofiber), dressings containing ionic silver, versus Algosteril (calcium alginate) dressings for 8 weeks among 134 diabetic patients with non-ischemic, Wagner (Grade 1 or 2) DFUs. The ionic silver dressing was better especially for healing of the infected ulcers and reduction of ulcer depth. Another research reported also the higher efficacy of silver hydrofiber dressings vs. the povidone dressing in healing of DFUs [24]**. Tsang *et al.*** [25] reported that Acticoat (nanocrystalline silver alginate) was potentially superior to Manuka honey in DFU size reduction rate. Many recent studies reported the efficacy of different silver dressings (silver colloids [26]**,** hydrogel/nanosilver [27]) versus normal saline dressings in managing DFUs.

To the best of our knowledge, the current study is the first to compare the efficacy of 2 different modern silver dressings in healing of DFUs, especially non-infected ones. Biatain® Ag foam was previously evaluated versus silver sulfadiazine cream in a 4-week study of 60 adult patients with infected DFUs. At week four, the silver sulfadiazine group's wound healing percentage was 27.00 ± 4.95%, vs 76.43 ± 7.41% for Biatain's ($p < 0.0001$) [28]. Previous studies, conducted on patients with partial-thickness burns, reported the higher efficacy of Mepilex Ag versus silver sulfadiazine cream [29], Acticoat (Nanocrystalline silver-coated polyethylene net) [30], and silver nanoparticle gel [31]**.**

Silver was the primary antimicrobial agent in the two dressings we used in the current research. The combination of consistent ionic silver release and improved dressing foam control of exudate may be the primary reasons why silver foam performs better than silver spray in wound healing [32]**.** Silver foam dressing used in the current study (Mepilex® Ag foam) has a Safetac technology. This technology involves the use of soft silicone that effectively adheres to dry, intact skin without adhering to the surface of a moist wound or fragile one [29]. Consequently, this dressing can be applied several times without damaging the wound or peri wound region [33]. The effective gentle seal that forms between the intact skin and the dressing with Safetac helps to prevent moisture-associated damage to the peri wound skin [34].

Limitations: The relatively small number of participants was one of these limitations. The strict measures of patient selection particularly the exclusion of patients with deep infected wounds and peripheral arterial disease limited the number of eligible participants. Furthermore, patients with diabetes frequently have multiple comorbidities, which led to their exclusion. Second, the cytotoxicity of the dressings under investigation was not assessed in the study. Lastly, this study included only patients with relatively superficial DFUs with no infection or ischemia (Texas 1A or 2A). Further studies directing silver dressing on varying DFUs severities will give clinicians better guidelines for wound dressing and management. The results of the current study may be different in the case of infected DFUs, as nanoparticles have the capability to reach biofilms in deep tissues [35]**.** Despite the study limitations, our results provided insights about the appropriate dressing to promote healing of non-infected non-ischemic DFUs.

CONCLUSION

Silver ion releasing foam dressing is significantly more effective than nanocrystalline silver spray in ulcer surface area reduction and complete neuropathic DFU healing with evident cost effectiveness.

Declaration of conflicting interests: Regarding the research, authorship, and/or publication of this paper, the authors disclosed no potential conflicts of interest.

Funding: The authors did not receive any funding for this research, authorship, and/or publication of this article.

REFERENCES

1. **Karakkattu V, Shalbha T, Vedavati B *et al.* (2014):** Choice of wound care in diabetic foot ulcer: A practical approach, World J Diabetes, 5 (4): 546–556.
2. **Abetz L, Sutton M, Brady L *et al.* (2002):** The diabetic foot ulcer scale: a quality of life instrument for use in clinical trials. Pract Diab Int., 19: 167-75.
3. **Wang C, Guo M, Zhang N *et al.* (2019):** Effectiveness of honey dressing in the treatment of diabetic foot ulcers: A systematic review and meta-analysis. Complementary therapies in clinical practice, 34: 123-131.
4. **Jeffcoate W, Kerr M (2022):** The costs of foot disease in diabetes in resource poor countries. Diabetic medicine: a journal of the British Diabetic Association, 39 (9): e14900.
5. **Schaper N, Van Netten J, Apelqvist J *et al.* (2023):** Practical guidelines on the prevention and management of diabetes-related foot disease. Diab Metab Res Rev., 40 (3): e3657.
6. **Wang H, Xu Z, Zhao M *et al.* (2021):** Advances of hydrogel dressings in diabetic wounds. Biomaterials science, 9 (5): 1530-46.
7. **Medici S, Peana M, Nurchi VM, *et al.* (2019):** Medical uses of silver: History, myths, and scientific evidence. J Med Chem., 62 (13): 5923–5943. doi: 10.1021/acs.jmedchem.8b01439.
8. **Alexander J (2009):** History of the medical use of silver. Surg Infect (Larchmt), 10 (3): 289–292. doi: 10.1089/sur.2008.9941.

9. **Matinfar M, Taheri S, Karimi S *et al.* (2021):** Successful treatment of peritoneal dialysis catheter exit-site granuloma with silver ion-based dressing. The Journal of Vascular Access, 22 (4): 685-6.
10. **Wilkinson L, White R, Chipman J (2011).** Silver and nanoparticles of silver in wound dressings: a review of efficacy and safety. Journal of wound care, 20 (11): 543-549.
11. **You C, Li Q, Wang X *et al.* (2017):** Silver nanoparticle loaded collagen/chitosan scaffolds promote wound healing via regulating fibroblast migration and macrophage activation. Scientific reports, 7(1): 10489.
12. **Liu X, Lee P, Ho C *et al.* (2010**): Silver nanoparticles mediate differential responses in keratinocytes and fibroblasts during skin wound healing. Chem Med Chem., 5 (3): 468-75.
13. **Leese G, Soto-Pedre E, Schofield C (2021):** Independent observational analysis of ulcer outcomes for SINBAD and university of Texas ulcer scoring systems. Diabetes Care, 44 (2): 326-31.
14. **Mayrovitz H, Smith J, Ingram C (1997):** Geometric, shape and area measurement considerations for diabetic neuropathic plantar ulcers. Ostomy Wound Manage, 43: 58-62.
15. **Storm-Versloot M, Vos C, Ubbink DT*et al.* (2010):** Topical silver for preventing wound infection. Cochrane Database Syst Rev., (3):17:(3):CD006478. doi: 10.1002/14651858.
16. **Lázaro-Martínez J, Álvaro-Afonso F, Sevillano-Fernández D *et al.* (2019):** Clinical and antimicrobial efficacy of a silver foam dressing with silicone adhesive in diabetic foot ulcers with mild infection. Int J Low Extrem Wounds, 18: 269–78.
17. **Leaper D, Münter C, Meaume S *et al.* (2013):** The use of Biatain Ag in hard- to-heal venous leg ulcers: meta-analysis of randomised controlled trials. PLoS One, 8 (7): e67083. https://doi.org/10.1371/journal. pone.0067083
18. **Dissemond J, Bottrich JG, Braunwarth H *et al.* (2017):** Evidence for silver in wound care meta-analysis of clinical studies from 2000-2015. J Dtsch Dermatol Ges., 15: 524–35.
19. **Luo Y, Li L, Zhao P *et al.* (2022):** Effectiveness of silver dressings in the treatment of diabetic foot ulcers: a systematic review and meta-analysis. Journal of Wound Care, 31 (11): 979-86.
20. **Wounds International (2012):** International consensus. Appropriate use of silver dressings in wounds. An expert working group consensus. Wounds International. www.woundsinternational.com/pdf/content_10381.pdf
21. **Revelli D, Lydikson C, Smith J (2011):** A unique silver sol with broad antimicrobial properties. Antimicrobial, 11: 5-16
22. **Zhang Y, Xing S (2014):** Treatment of diabetic foot ulcers using Mepilex Lite Dressings: a pilot study. Exp. Clin. Endocrinol. Diabetes 122:227–230. doi: 10.1055/s-0034-1370918
23. **Jude E, Apelqvist J, Spraul M *et al.* (2007):** Prospective randomized controlled study of Hydrofiber dressing containing ionic silver or calcium alginate dressings in non-ischaemic diabetic foot ulcers. Diabetic Med., 24: 280-88.
24. **Suvarna R, Viswanadh K, Hanumanthappa M *et al.* (2016):** A comparative study between hydrofiber dressing, povidone dressing in diabetic foot ulcers. J. Evid. Based Med. Health c., 3: 986–991. doi: 10.18410/jebmh/2016/226.
25. **Tsang K, Kwong E, To T *et al.* (2017):** A pilot randomized, controlled study of nanocrystalline silver, manuka honey, and conventional dressing in healing diabetic foot ulcer. Evidence-Based Complementary and Alternative Medicine, 1: 5294890.
26. **Tajdar Y, Singh S, Raj A *et al.* (2024):** Effect of silver colloid dressing over conventional dressings in diabetic foot ulcer: A prospective study. Turkish Journal of Surgery, 40 (1): 028-35.
27. **Yahia E, El-Sharkawey A, Bayoumi M (2021):** Quantitative evaluation of diabetic foot wound healing using hydrogel nanosilver based dressing vs. traditional dressing: A prospective randomized control study. Pak. J. Med. Health Sci., 15: 1571-4.
28. **Wang Y, Lee H, Chen C *et al.* (2021):** The Effects of Silver-Releasing Foam Dressings on Diabetic Foot Ulcer Healing. J. Clin. Med., 10: 1495. https://doi.org/10.3390/ jcm10071495
29. **Silverstein P, Heimbach D, Meites H *et al.* (2011):** An open, parallel, randomized, comparative, multicenter study to evaluate the cost effectiveness, performance, tolerance, and safety of a silver-containing soft silicone foam dressing (intervention) vs silver sulfadiazine cream. J Burn Care Res., 32 (6): 617–626.
30. **GeeKee E, Kimble R, Cuttle L *et al.* (2015).** Randomized Controlled Trial of Three Burns Dressings for Partial Thickness Burns in Children. Burns, 41: 946–955.
31. **Erring M, Gaba S, Mohsina S *et al.* (2019):** Comparison of efficacy of silver-nanoparticle gel, nano-silver-foam and collagen dressings in treatment of partial thickness burn wounds. Burns, 45 (8): 1888-94.
32. **Senet P, Bause R, Jorgensen B *et al.* (2014):** Clinical efficacy of a silver-releasing foam dressing in venous leg ulcer healing: A randomised controlled trial. Int. Wound J., 11: 649–655.
33. **Zillmer R, Agren M, Gottrup F *et al.* (2006):** Biophysical effects of repetitive removal of adhesive dressings on peri-ulcer skin. J Wound Care, 15 (5): 187–191. doi:10.12968/jowc.2006.15.5.26907.
34. **Meaume S, Van De Looverbosch D, Heyman H *et al.* (2003):** A study to compare a new self-adherent soft silicone dressing with a self-adherent polymer dressing in stage II pressure ulcers. Ostomy Wound Manage, 49 (9): 44–51.
35. **Huang D, Wang J, Ren K *et al.* (2020):** Functionalized Biomaterials to Combat Biofilms. Biomater. Sci., 8: 4052–4066.