e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2026; 17(2); 01-06

Original Research Article

Efficacy of Nanocrystalline Silver Dressing in Diabetic Foot Ulcers

Konappa V.[1], Santhosh Urs K. S.[2], Sachin H. G.[3], Bhushan M.[4]

[1]Associate Professor, Department of General Surgery, Chikkamagaluru Institute of Medical Science, Karnataka, India

[2]Assistant Professor, Department of General Surgery, Chikkamagaluru Institute of Medical Science, Karnataka, India

[3]Assistant Professor, Department of General Surgery, Chikkamagaluru Institute of Medical Science, Karnataka, India

[4]Assistant Professor, Department of General Surgery, Chikkamagaluru Institute of Medical Science, Karnataka, India

Received: 01-11-2025 / Revised: 15-12-2025 / Accepted: 21-01-2026
Corresponding author: Dr. Bhushan M
Conflict of interest: Nil

Abstract

Background: Diabetes mellitus is a chronic metabolic disorder associated with long-term complications, among which diabetic foot ulcer (DFU) is one of the most common and debilitating. DFUs frequently result in prolonged hospitalization, increased risk of infection, and limb amputation. Conventional wound dressings have limitations in infection control and healing efficiency.

Aims: To evaluate the efficacy of nanocrystalline silver dressings in the management of diabetic foot ulcers.

Methodology: This prospective comparative study was conducted at Chikkamagaluru Institute of Medical Science over a one-year period (01.08.2024–01.08.2025). A total of 100 patients with Wagner's grade II diabetic foot ulcers were randomly allocated into two groups: Group A (nanocrystalline silver dressing, n=50) and Group B (conventional dressing, n=50). Outcomes assessed included number of dressings required, percentage reduction in ulcer size (measured using ulcer planometry), and length of hospital stay.

Results: Group A demonstrated significantly better outcomes compared to Group B. The mean number of dressings required was lower (10.28 vs 21.74), mean hospital stay was shorter (20.26 vs 43.16 days), and mean percentage reduction in ulcer size was higher (95.24% vs 83.32%). These differences were statistically significant.

Conclusion: Nanocrystalline silver dressings are safe, effective, and superior to conventional dressings in the management of diabetic foot ulcers, offering faster healing, reduced hospital stay, fewer dressing changes, and better patient compliance.

Keywords: Diabetic Foot Ulcer; Nanocrystalline Silver Dressing; Wound Healing; Conventional Dressing.

DOI: 10.25258/ijpqa.17.2.1

Introduction

Diabetes is a metabolic disease characterised by hyperglycaemia, which may be due to defect in insulin secretion, insulin action or both and is associated with failure of different organs, especially the eyes, kidneys, nerves and heart. [1, 2] India with approximately 42 million cases is ranked first in the list of ten nations most affected with diabetes. [3] Foot ulceration is the most common complication affecting 15% of them. [4,5] They require prolonged hospitalisation and has risk of limb amputation. [6]

Peripheral neuropathy, peripheral vascular disease, and foot trauma were risk factors in the pathophysiology of foot ulcer. [7,8,9,10] Numerous dressings are available like Saline, hydrogels, hydrocolloid, foam, and alginate, Paraffin (Tulle), Polyurethane, silver impregnated dressings. [11, 12] Nanocrystalline silver ion dressing is an effective antimicrobial barrier composed of an absorbent inner core that maintains a moist environment optimal for wound healing and outer layers of silver coated polyethylene nets which prevent wound contamination and exhibit bactericidal effect. [13,14] There are several mechanisms by which Ag NPs can destroy the bacteria. They include bacterial membrane destruction, the crossing of the microbial body and initiation of intracellular destruction, removal of lipopolysaccharide with cellular disintegration, the induction of oxidative stress, and metal release ions in addition to non-oxidative stress mechanisms. [15,16,17]

In addition to antimicrobial properties that have been well demonstrated in vitro in the literature, silver dressings are proven to reduce the bacterial load present in an infected wound, in turn reducing the inflammatory response and further aiding the healing process. [18] Silver based dressing materials contain Silver nano particles - which expand the surface area of contact with the wound and also are in the ionic form Ag cations which cause cell toxicity to bacteria both gram positive and negative, including multi drug resistant strains and also promoting wound healing by the inhibition of MMPs and are also effective against bio films. [19,20]

Aim of the Study: To study the efficacy of Nano crystalline silver dressing in diabetic foot ulcer.

Objectives: The efficacy of Nano crystalline silver dressings is assessed in terms of number of dressing required, Percentage reduction in the ulcer size, Length of hospital stay.

Patients and Methods: This was a Prospective, Comparative study done in Chikkamagaluru Institute of Medical Science, in 100 patients with Diabetic Foot Ulcers divided into two Groups with 50 patients in each group for 1 year period from 01.08.2024 to 01.08.2025.

Inclusion Criteria: Patients above 18 years with diabetic foot ulcer of Wagner's grade II.

Exclusion Criteria: Patients with comorbidities like Cardiovascular, Respiratory, Neurological, and Osteomyelitis, Ischemic, malignant, venous insufficiency and Ulcers of Wagner's grade III, IV, and V. Patients admitted in the Department of General Surgery at Chikkamagaluru Institute of Medical Science were divided into Group A (Nano silver crystalline dressings) and Group B (Conventional dressings). Upon admission history of the mode of onset, duration, progress of ulcer and information about diabetes status with duration and medication. Ulcer examination and investigations like Hemoglobin, Blood Sugars, Serum Creatinine, Urine Ketone Bodies, X ray foot, Doppler (both arterial and venous). Patients were discharged from the hospital after significant reduction in ulcer size or in some cases after formation of granulation tissue and after applying partial thickness split skin graft. Percentage reduction in the ulcer size was measured at the time of discharge using Ulcer Planometry. Number of dressings required for each group, Number of days of hospital stay were recorded. Patients are re-evaluated on the outpatient basis for 2 months.

Statistics: Data was entered in Microsoft excel and analyzed. The results are presented in frequencies, percentages and Mean, Standard Deviation. Relevant statistical analysis was done using SPSS version 16. Differences in the groups was analysed with Chi square test, Continuity Correction, Likelihood Ration, Fisher's Exact Test, McNemar Test. Significance was defined when the p valve is less than 0.05.

Results

Table 1: Age-Wise Distribution in Total Sample (N=100)

Age in years	**No of patients**	**Percentage**
20-30	2	2
31-40	7	7
41-50	25	25
51-60	40	40
61-70	21	21
71-80	5	5
Mean 56.02	**Std. Deviation 10.315**	
Male	64	64
Female	36	36

Table 2: Binomial Analysis of Ulcer Onset in Total Sample

Binomial Test					
Ulcer Onset	**Category**	**N**	**Observed Prop.**	**Test Prop.**	**Exact Sig. (2-tailed)**
	Traumatic	69	0.69	0.50	<0.001
	Spontaneous	31	0.31		
	Total	100	1.00		

Table 3: Binomial Analysis of Ulcer Onset in Groups

Binomial Test					
	Category	**N**	**Observed Prop.**	**Test Prop.**	**Exact Sig. (2-tailed)**
Ulcer in Group 1	Traumatic	37	0.74	0.50	<0.001
	Spontaneous	13	0.26		
	Total	50	1.00		
Ulcer In Group 2	Spontaneous	18	0.36	0.50	0.065
	Traumatic	32	0.64		

Table 4: A Binomial Analysis of Ulcer Site in Total Sample

Binomial Test				
Category	**N**	**Observed Prop.**	**Test Prop.**	**Exact Sig. (2-tailed)**
Plantar	69	.69	.50	<.001
Dorsal	31	.31		
Total	100	1.00		

Table 5: Binomial Analysis of Ulcer Site in Groups

	Ulcer Site Binomial Test				
	Category	**N**	**Observed Prop.**	**Test Prop.**	**Exact Sig. (2-tailed)**
Group 1	Plantar	38	0.76	0.50	<.001
	Dorsal	12	0.24		
	Total	50	1.00		
Group 2	Plantar	31	0.62		
	Dorsal	19	0.38	0.50	0.119
	Total	50	1.00		

Table 6: Binomial Analysis of Treatment in Groups

Binomial Test					
	Category	**N**	**Observed Prop.**	**Test Prop.**	**Exact Sig. (2-tailed)**
Group 1	OHA	17	0.34	0.50	0.033
	Insulin	33	0.66		
	Total	50	1.00		
Group 2	Insulin	22	0.44	0.50	0.480
	OHA	28	0.56		
	Total	50	1.00		

Table 7: A Descriptive Analysis of Outcome and Dependent Variables

Statistics							
		Group 1			**Group 2**		
		No of Dressings	**LOS**	**% reduction in ulcer size**	**No of Dressings**	**LOS**	**% reduction in ulcer size**
N	Valid	50	50	50	50	50	50
	Missing	80	80	80	80	80	80
Mean		10.2800	20.2600	95.2400	21.7400	43.1600	83.3200
Std. Deviation		2.82149	5.64172	2.64621	3.89039	7.86716	6.11936
Range		12.00	24.00	11.00	13.00	26.00	24.00
Percentiles	10	7.0000	12.2000	91.1000	16.1000	32.1000	72.2000
	20	8.0000	16.0000	94.0000	18.0000	35.0000	78.0000
	30	8.0000	16.0000	94.0000	19.0000	36.3000	80.0000
	40	9.0000	17.4000	95.0000	20.4000	40.4000	84.0000
	50	10.0000	20.0000	96.0000	22.0000	43.5000	86.0000
	60	12.0000	23.2000	96.0000	23.6000	46.0000	86.0000
	70	12.0000	24.0000	97.0000	24.0000	48.0000	88.0000
	80	13.0000	26.0000	98.0000	25.0000	50.0000	88.0000
	90	14.0000	28.0000	98.0000	27.0000	54.0000	90.0000

Discussion

As of routine practice there are many methods of dressings that are done for the Diabetic foot. They include: Povidone Iodine [21] Cadexomer Iodine, Metronidazole. [22]

In our study we used Nanosilver as a dressing material and compared with conventional dressing materials. Silver nanocrystalline technology utilizes nano-scale silver particles to enhance the antimicrobial properties of silver, making it highly effective against various microorganisms.

Mechanism of Action: Silver ions (Ag+) bind to tissue proteins, causing structural changes in bacterial cell membranes, inhibiting cell replication, and denaturing bacterial DNA and RNA. It is effective against bacteria, fungi, yeast, mold, and antibiotic-resistant strains like MRSA and VRE. It maintains adequate concentrations of silver (>70mg/L) with prolonged residual activity, preventing microbial resistance. [23,24]

Benefits: Provides moisture to the wound bed, preventing dehydration of granulation tissue and promoting autolytic debridement. It allows gaseous exchange while forming a barrier against microbial entry into the wound.

It offers a cooling effect, soothing pain associated with wounds. It releases active ionic silver slowly over time, ensuring broad antimicrobial effectiveness and preventing contamination. It decreases wound surface contamination, aiding in the healing process. It promotes wound healing by inhibiting MMPs involved in tissue breakdown.It can be used in pressure ulcers, venous ulcers, dermal lesions, second-degree burns, and donor sites.

There are no absolute contraindications but its utility is limited when used in heavily exudating wounds or wounds covered with thick eschar.

Table 8: Descriptive Analysis of Treatment Variables

Descriptive Statistics						
		Statistic	Bootstrap[a]			
			Bias	Std. Error	95% Confidence Interval	
					Lower	Upper
Group 1						
No of dressings	N	50	0	0	50	50
	Minimum	4.00				
	Maximum	16.00				
	Mean	10.2800	0.0052	0.3834	9.5600	11.0995
	Std. Deviation	2.82149	-0.03608	0.19788	2.40442	3.17343
LOS	N	50	0	0	50	50
	Minimum	8.00				
	Maximum	32.00				
	Mean	20.2600	0.0134	0.7682	18.8000	21.8390
	Std. Deviation	5.64172	0.07634	0.40052	4.74610	6.33363
% reduction in ulcer size	N	50	0	0	50	50
	Minimum	88.00				
	Maximum	99.00				
	Mean	95.2400	0.0018	0.3724	94.5200	95.9600
	Std. Deviation	2.64621	0.04883	0.32859	1.95891	3.19422
Group 2						
No of dressings	N	50	0	0	50	50
	Minimum	16.00				
	Maximum	29.00				
	Mean	21.7400	0.0017	0.5511	20.6410	22.9000
	Std. Deviation	3.89039	0.04437	0.27101	3.29025	4.35740
LOS	N	50	0	0	50	50
	Minimum	32.00				
	Maximum	58.00				
	Mean	43.1600	0.0018	1.1160	41.0200	45.4600
	Std. Deviation	7.86716	0.08685	.54607	6.66899	8.83068
% reduction in ulcer size	N	50	0	0	50	50
	Minimum	68.00				
	Maximum	92.00				
	Mean	83.3200	-0.0192	0.8369	81.6800	84.8795
	Std. Deviation	6.11936	0.08322	0.56093	4.92512	7.07785
Valid N	N	50	0	0	50	50
a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples						

In Dr. P. Nancharaiah MS et al [25] study maximum patients were in the age group of 51-60 years. In N. V. Ramanaiah et al. [26] study most of the patients were in the age group of 51-60 years. In Kanneedi naresh kumar et al. [27] study more number of patients in Test Group and Control Group were in age group of 51-60. In Luo et al. [28] study mean age of sample was 48.30 to 59.20 years. In a study done by Dr. Shiva kumar. S et al. [29] more number of patients were males as our study. In Dr. P. Nancharaiah MS et al [25] 80% ulcers were due to trauma, and 20% were spontaneous. In N. V. Ramanaiah et al [26] study 69% ulcers were traumatic origin and 31% were spontaneous in onset. In N. V. Ramanaiah et al [26] study 69% ulcers are on plantar area; and in Kanneedi naresh kumar et al [27] study also plantar ulcers were more common than ulcers on the dorsum. In a study done by Tsang. K. K.et al [30] they noticed that stay is less in Nano silver dressings compared to conventional and manuka honey dressings. In Rahaman, Abdur et al [31] study the duration of stay was shorter in nanosilver group with mean difference of 6.63 days. In a study done by Luo et al [28] showed that the use of silver dressings associated with shorter hospital stay compared to other dressings.

Rakesh sharma et al [32] in their study found that 80% of wounds healed within 3 wks in test group, where as in control group only 28% of wounds healed. Dr. Madala samba siva rao et al [33] in their study noticed that 18% patients are staying for the duration of 5 weeks in control group, but no patients stayed for 5 wks in study group.

In our study mean of number of dressings required in test group found to be 10.28 ± 2.82 and in control group it was 21.74 ± 3.89. Dr. Madala samba siva rao et al [33] in their study noticed that in conventional dressings group 26-30 dressings were done for 12% cases & 16-20, 21-25 dressings were done for 30% of cases each and in Nano Crystalline Silver group no cases required more than 20 dressings.

In our study mean of percentage of reduction in ulcer size was found to be 95.24 ± 2.64 in test group where as in control group it was 83.32 ± 6.11. The results in our study were comparable with the following studies.

In Rahaman, Abdur et al [31] high healing rates were noted in nano silver group from 2nd week compared to povidone iodine group. Dr. Madala samba siva rao et al [33] in their study percentage area of reduction in ulcer size in study group was 41-50% in 54% of patients and only 11-20% reduction was seen in 68% patients of control group.

Conclusion

From the study we conclude that Nanocrystalline silver dressings are safe, effective, with a slight beneficial edge when compared to conventional dressings in terms of promoting wound healing, and more patient compliant in terms of Less pain while changing the dressing, Less number of dressings, Shorter hospital stay, More percentage reduction in ulcer size.

The above results indicates that nanocrystalline silver dressings may be used in the management of diabetic foot ulcers and are seems to be more efficient than conventional dressings.

References

1. American Diabetes Association. Standards of Medical Care in Diabetes-2014. Diabetes Care.2014; 37(1):14-80.
2. Frykberg RG. Diabetic foot ulcers: pathogenesis and management. Am Fam Phys. 2002;66(9):1655.
3. Ramachandran A, Ma RC, Snehalatha C. Diabetesin Asia. The Lancet. 2010;375(9712): 408-18.
4. Viswanathan V, Shobhana R, Snehalatha C, Seena R, Ramachandran A. Need for education on footcare in diabetic patients in India. J Assoc Physic Ind. 1999;47(11):1083-5.
5. Viswanathan V, Kumpatla S. Pattern and Causes of Amputation in Diabetic Patients – A Multicentric Study from India. 2011; 59:5.
6. Fatima Habbash, Afrah Saeed, Fadheela Abbas, Buthaina Yousif Ajlan, Fatima Abdulla, Adel Salman Al-Sayyad, Prevalence of risk factors for diabetic foot complications BMC Family Int J Med. Public Health. 2019; 9(4):148-153.
7. Fong J, Wood F. Nanocrystalline silver dressings in wound management: a review. Int J Nanomedicine. 2006;1(4):441–9.
8. Joshi SR, Parikh RM. India – diabetes capital of the world: now heading towards hypertension. J Assoc Physicians India. 2007; 55:323-24.
9. Kumar A, Goel MK, Jain RB, Khanna P, Chaudhary V. India towards diabetes control: Key issues. Australas Med J. 2013; 6:524-31.
10. Bowering CK. Diabetic foot ulcers: pathophysiology, assessment, and therapyCan Fam Phys. 2001;47:1007-16.
11. Hilton JR, Williams DT, Beuker B, Miller DR, Harding KG. Wound Dressings in Diabetic Foot Disease. Clinical Infectious Diseases. 2004;39(2): S100-03.
12. Kavitha KV, Tiwari S, Purandare VB, Khedkar S, Bhosale SS, Unnikrishnan AG. Choice of wound care in diabetic foot ulcer: A practical approach. World J Diabetes. 2014;5(4):546-56.

13. Munteanu A, Florescu IP, Nitescu C. A modern method of treatment: The role of silver dressings in promoting healing and preventing pathological scarring in patients with burn wounds. J Med Life. 2016;9(3):306-15.
14. Muangman P, Chuntrasakul C, Silthram S, Suvanchote S, Benjathanung R, etal. Comparison of efficacy of 1% silver sulfadiazine and Acticoat for treatment of partial-thickness burn wounds. Med Assoc Thai. 2006; 89(7):953-58.
15. Le Ouay B, Stellacci F. Antibacterial activity of sil- ver nanoparticles: a surface science insight. Nano Today. 2015; 10:339-354.
16. Franci G, Falanga A, Galdiero S, et al. Silver nanoparticles as potential antibacterial agents. Molecules. 2015; 20:8856-8874.
17. Wang L, Hu C, Shao L. The antimicrobial activity of nanoparticles: present situation and prospects for the future. Int J Nanomedicine. 2017; 12:1227-1249.
18. Lin Y, Hsu W, Chung W, Ko T, Lin J. Silver-based wound dressings reduce bacterial burden and promote wound healing. Int Wound J. 2016; 13:505-511.
19. Murphy, P. S., & Evans, G. R. (2012). Advances in wound healing: a review of current wound healing products. Plastic surgery international, 2012.
20. Warriner, R., & Burrell, R. (2005). Infection and the chronic wound: a focus on silver. Advances in skin & wound care, 18(8), 2-12.
21. Elizabeth A, Janet E. Debridement: Controlling the Necrotic/Cellular Burden. Advances in Skin & Wound Care: The Journal for Prevention and Healing 2004 mar; 17(2): 66 – 75.
22. K.D. Tripathi, The Essentials of Medical Pharmacology, 6th edition, 798-799.
23. B. S. Atiyeh, M. Costagliola, S. N. Hayek, and S. A. Dibo, "Effect of silver on burn wound infection control and healing: review of the literature," Burns, vol. 33, no. 2, pp. 139–148,2007.
24. R. Khundkar, C. Malic, and T. Burge, "Use of Acticoat dressings in burns: what is the evidence?" Burns, vol. 36, no. 6, pp. 751–758, 2010.
25. Dr. P. Nancharaiah MS, A Comparative Study Between Conventional and Nano silver Dressings In Patients with Diabetic Ulcer." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 17, no. 1, 2018, pp. 39-32.
26. Dr. N. V. Ramanaiah, Saikrishna, Chandrasekhar, Vamshidhar, G. V. Ramanaiah, K. Lokesh. "A Clinical Study on Efficacy of Nanocrystalline Silver Dressing in Diabetic Foot Ulcers". Journal of Evidence based Medicine and Healthcare; Volume 2, Issue 45, November 05, 2015; Page: 8160-8170,
27. Kanneedi Naresh Kumar, G. Sashikalyan Topical Silver Dressing versus Conventional Saline Dressing in the Management of Non-Healing Ulcers: A Prospective Randomized Interventional Study, International Journal of Pharmaceutical and Clinical Research 2023; 15(5); 795-801
28. Luo, Yixin& Li, Li & Zhao, Ping & Yang, Chuan& Zhang, June. (2022). Effectiveness of silver dressings in the treatment of diabetic foot ulcers: a systematic review and meta-analysis. Journal of Wound Care. 31. 979-986. 10.12968/jowc.2022.31.11.979.
29. N, Ravishankar & S, Shivakumar & K, Abirami. (2020). A comparative study of ionic silver-based dressings versus conventional dressings in management of diabetic foot ulcers. International journal of scientific research. 77-79. 10.36106/ijsr/4322859.
30. Tsang KK, Kwong EW, To TS, Chung JW, Wong TK. A Pilot Randomized, Controlled Study of Nanocrystalline Silver, Manuka Honey, and Conventional Dressing in Healing Diabetic Foot Ulcer. Evid Based Complement Alternat Med. 2017; 2017:5294890.
31. Rahaman, Abdur, et al. "Nanosilver versus Povidone iodine dressing-efficacy in the management of chronic diabetic foot ulcers." Journal of Evolution of Medical and Dental Sciences, vol. 6, no. 22, 16 Mar. 2017, pp. 1799
32. Sharma R, Rajkamal, Kumar R, Mittal S, Kaur A. Study of effect of topical nano silver gel on wound healing. J Adv Med Dent Scie Res 2016;4(5):59-61.
33. Dr. Madala Sambasivarao et al Efficacy of conventional dressings versus nanocrystalline silver dressings in diabetic foot ulcers: a clinical study. 2022 International Journal of Scientific Research, Volume 11, Issue 1, January 2022.