Al-Azhar International Medical Journal

Volume 5 | Issue 4 Article 18

4-30-2024

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Ahmed Mahmoud Al-Ashmawy
General Surgery, Faculty of Medicine Al-Azhar University, Cairo, Egypt, ahmedalashmawy8@gmail.com

El-Sayed Ahmed Hamdy
General Surgery, Faculty of Medicine Al-Azhar University, Cairo, Egypt

Abd Elrahman Safwat Elkady
General Surgery, Faculty of Medicine Al-Azhar University, Cairo, Egypt

How to Cite This Article

Al-Ashmawy, Ahmed Mahmoud; Hamdy, El-Sayed Ahmed; and Elkady, Abd Elrahman Safwat (2024) "Evaluation of the Antimicrobial Effect of Contact Eye Lenses Solution on The Infected Wounds," *Al-Azhar International Medical Journal*: Vol. 5: Iss. 4, Article 18.
DOI: https://doi.org/10.58675/2682-339X.2362

ORIGINAL ARTICLE

Evaluation of the Antimicrobial Effect of Contact Eye Lenses Solution on The Infected Wounds

Ahmed M. Al-Ashmawy *, El-Sayed A. Hamdy, Abd Elrahman S. Elkady

Department of General Surgery, Faculty of Medicine Al-Azhar University, Cairo, Egypt

Abstract

Background: ***Wounds are commonplace in routine life, disasters, accidents, war, surgery, and infection.***

Objective: ***To evaluate the antimicrobial effect of contact eye solution on wound infection, including the amount and nature of discharge, frequency of daily dressing, rate of healing, hospital stays, and returns to usual activities.***

Patients and methods: ***This Preoperative Randomized Controlled trial was performed on 40 patients with infected wounds grades I, II, III, and IV, diabetic foot grades 0(a, b), I (a, b), and aged between 16 to 50 years old at Al-Azhar University and Nasser Institute Hospital for six. Cases were subdivided into two groups: Group A: patients use contact lens solution, and Group B: Patients use povidone-iodine solution.***

Results: ***The time to complete healing was significantly shorter in the Contact eye solution compared to the Povidone-iodine group. Hospital stay was significantly shorter in the Contact eye solution compared to the Povidone-iodine group (p= <.001). Time to return to usual activity is significantly faster in the Contact eye solution compared to the Povidone-iodine group. Daily dressing was significantly lower in the Contact eye solution compared to the Povidone-iodine group. Staining was significantly different between the two studied groups (p= 0.017). Dermatitis was insignificantly different between the two studied groups (p= 0.072).***

Conclusions: ***Comparable to Povidone-iodine dressing in wound infection, contact lens solution dressing offers superior wound healing safety and efficacy.***

Keywords: Antimicrobial effect, Contact eye lenses solution, infected wounds, Povidone-iodine

1. Introduction

Wounds are commonplace in routine life, disasters, accidents, war, surgery, and infection. The most severe complication in wound healing is bacterial infection, which can result in delayed healing, suppuration, necrosis in the tissue, and even amputation. [1]

Following the disruption of the skin's integrity, the body produces an immediate response followed by a comparable and functional period of regeneration, known as wound healing. Five significant steps comprise the wound healing procedure: homeostasis and inflammation, granulation tissue formation, neovascularization, re-epithelialization, and remodeling. These stages are carefully controlled by a cascade of internal and external stimuli, including cytokines and growth factors, resulting in regeneration and restoration of the damaged skin. Grading of wound infection is essential to detect the optimal Precautions. [2]

For Diabetic Foot: The University of Texas Diabetic Foot Ulcer Classification System has been demonstrated to accurately predict the amputation of the lower extremity. To categorize DFUs, this system employs four stages (A–D) and four grades (0–3). The stages represent the wound's severity by indicating the presence of ischemia, infection, or both, whereas the grades correlate to wound depth. [3]

Accepted 14 April 2024.
Available online 30 April 2024

* Corresponding author at: General Surgery, Faculty of Medicine Al-Azhar University, Cairo, Egypt
E-mail address: ahmedalashmawy8@gmail.com (A. M. Al-Ashmawy).

https://doi.org/10.58675/2682-339X.2362

For post-surgical wound infection: Southampton wound-grading system. Materials used for wound dressing play a crucial role in healing. [4, 5]
Contact lens solution contains disodium edetate, boric acid, NaC1, and sodium borate. Active ingredients DYMED (Poly hexamethylene biguanide) 0.00005%. Poloxamine 1% component has antibacterial and antifungal effects in addition to increased proliferation of cells, migration of fibroblasts, growth factor, and gene expression levels of dermal cells. [6, 7]
All these benefits allow us to evaluate the effect of contact lens solutions on infected wounds.
Our objective was to evaluate the antimicrobial effect of contact eye solution on wound infection, including the amount and nature of discharge, frequency of daily dressing, rate of healing, hospital stays, and returns to usual activities.

2. Patients and methods

This Preoperative Randomized Controlled trial was performed on 40 patients with infected wounds in grades I, II, III, IV. Diabetic foot grades 0(a, b), I (a, b), and aged between 16 to 50 years old at Al-Azhar University and Nasser Institute Hospital for six months from July to December 2022. Informed written consent was acquired from the patient or the patient's family. The trial was conducted after approval from the Ethical Committee, a local ethical committee of the Faculty of Medicine, Al-Azhar University.
Exclusion criteria were severe sepsis, infected wounds grades V, diabetic foot grades 0(c, d), I (c, d), II, III, Ischaemic limbs, horrible general condition, and usage of antimicrobial drugs.
Grouping: The 40 cases in this trial were prospectively subdivided into two major groups: Group A: Patients use a contact lens solution, and Group B: Patients use a povidone-iodine solution.
All cases underwent the following: Detailed history taking, including personal data: name, sex, age, occupation, and address. History of previous surgical operations, abdominal surgeries, hospital diagnosis, admission date in hospital, Medical history, and past history (DM, HTN).
Detailed clinical examination: A. General: pulse, blood pressure, respiration, cardiovascular and neurological assessment. Weight measurement. B. Local examinations for infected wounds and ulcers and their classification are performed.
Laboratory Investigations: Complete blood picture (CBC): red blood cells (RBCs), hemoglobin concentration (Hb %), white blood cells (WBCs), platelet count. Testing of the renal function: urine analysis, blood urea, and serum creatinine. Testing of the Liver Profile: Serum alanine and aspartate aminotransferases (ALT and AST), serum bilirubin, serum albumin, prothrombin time, and international normalized ratio (INR). Coagulation profile (INR, APTT, platelets, and fibrinogen).Swab biopsy for culture and sensitivity. HCV, HBV, HIV.
Albumin, RBS, HBA1C.
Radiological assessment of the wound: According to the cause and site of infected wound
Ultrasound, Duplex for diabetic foot, X-ray for diabetic foot
Surgical Procedures:
Debridement of all necrotic tissues.
Cases in this trial were subdivided into two major groups prospectively:
Group A: Patients use contact lens solution:
Irrigate the wounds with normal saline, then put them on contact lens solution for 3-5 minutes, and apply non-soaked packing.
Group B: Patients use povidone-iodine solution:
Irrigate the Wounds with normal saline, then apply a povidone-iodine solution for 3-5 minutes, and then apply non-soaked packing.
Statistical analysis
SPSS v27 (IBM©, Armonk, NY, USA) was used for the statistical analysis. Histograms and the Shapiro-Wilks test were employed to assess the normality of the data distribution. When appropriate, categorical data were displayed as frequency and percentage (%) and analyzed using the Chi-square test or Fisher's exact test. Quantitative parametric variables were displayed as mean and standard deviation (SD) and were analyzed using an unpaired student t-test. Quantitative non-parametric variables were displayed as the median and interquartile range (IQR) and were analyzed using the Mann Whitney-test. A two-tailed P value < 0.05 was deemed statistically significant.
Cases presentation (Figure 1)

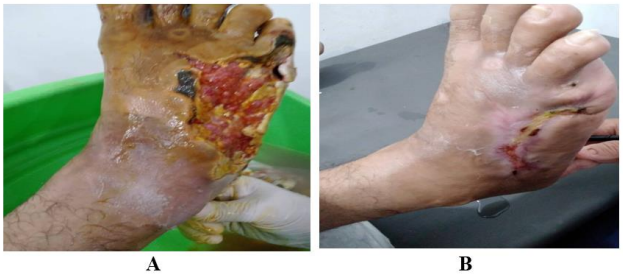

Figure 1. (A) Infected Diabetic foot and (B) healed diabetic foot within 24 days

3. Results

Regarding Gender, age, and BMI, no significant variation between the two studied groups was reported. The etiology of the wound was insignificantly different between the two studied groups (p= 1). Table 1

Table 1. Demographic characteristics and Etiology of wound among the study group

		CONTACT EYE SOLUTION GROUP (N = 20)	POVIDONE-IODINE GROUP (N = 20)	TEST OF SIG.	P
SEX	Male	16 (80%)	13 (65%)	X2 =	0.288
	Female	4 (20%)	7 (35%)	1.129	
AGE (YEARS)	Mean ± SD.	32.95 ± 6.66	32.7 ± 6.07	t = 0.124	0.902
	Range (Min-Max)	25 (20 - 45)	23 (23 - 46)		
BODY MASS INDEX	Mean ± SD.	26.9 ± 3.26	27.55 ± 3.25	t = -0.631	0.532
	Range (Min-Max)	13 (20 - 33)	13 (20 - 33)		
ETIOLOGY OF WOUND	Post-laparotomy surgery	6 (30%)	7 (35%)	X2 = 0	1
	Breast surgery	5 (25%)	4 (20%)		
	Diabetic foot	3 (15%)	4 (20%)		
	Incisional hernia	6 (30%)	5 (25%)		

x2: Chi- Square test SD: standard deviation IQR: interquartile range

t: Independent T test p: p value for comparing between the studied groups.

P-value < 0.05: Significant; P-value < 0.001: Highly significant

Swab culture test results among the study groups. The swab culture test revealed insignificant variation between the two studied groups (p= 0.811). Table 2

Table 2. Swab culture test results among the study groups

	CONTACT EYE SOLUTION GROUP (N = 20)	POVIDONE-IODINE GROUP (N = 20)	TEST OF SIG.	P
SWAB CULTURE TEST RESULTS			X2 =	0.811
E. COLI	9 (45%)	11 (55%)	0.42	
STAPH	7 (35%)	6 (30%)		
PSEUDOMONAS	4 (20%)	3 (15%)		

x2: Chi- Square test p: p value for comparing between the studied groups

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.001: Highly significant

WBC, RBC, and Platelet were insignificantly different between both groups. Fasting blood sugar PPBS and HBA1C were insignificantly different between both groups. ALT and AST were insignificantly different between both groups. Serum protein test results among the study groups. Total protein and Albumin were insignificantly different between both groups. Table 3

Table 3. Complete blood count test, Blood sugar test, Liver Function Test, and Serum protein test results among the study groups

		CONTACT EYE SOLUTION GROUP (N = 20)	POVIDONE-IODINE GROUP (N = 20)	TEST OF SIG.	P
WBC (103/ML)	Mean ± SD.	7.03 ± 0.87	7.17 ± 0.88	t = -0.524	0.603
	Range (Min-Max)	3.4 (5.4 - 8.8)	3.6 (5.7 - 9.3)		
RBC (106/ML)	Mean ± SD.	5.09 ± 0.63	4.9 ± 0.6	t = 0.946	0.35
	Range (Min-Max)	2 (4 - 6)	2.1 (3.7 - 5.8)		
PLATELET(103/ML)	Mean ± SD.	262.4 ± 32.34	265.6 ± 32.62	t = -0.312	0.757
	Range (Min-Max)	109 (198 - 307)	124 (203 - 327)		
FASTING BLOOD SUGAR	Mean ± SD.	89 ± 11.16	88.65 ± 10.34	t = 0.103	0.919
	Range (Min-Max)	40 (79 - 119)	38 (82 - 120)		
POST PRANDIAL BLOOD SUGAR	Mean ± SD.	189.3 ± 12.79	188.85 ± 9.63	t = 0.126	0.901
	Range (Min-Max)	46 (168 - 214)	39 (175 - 214)		
HBA1C	Mean ± SD.	5.18 ± 0.51	5.14 ± 0.44	t = 0.301	0.765
	Range (Min-Max)	1.7 (4.5 - 6.2)	1.6 (4.7 - 6.3)		
ALT	Mean ± SD.	37.6 ± 4.63	39.1 ± 4.68	t = -1.02	0.314
	Range (Min-Max)	16 (29 - 45)	17 (31 - 48)		
AST	Mean ± SD.	35.2 ± 4.44	35.05 ± 4.25	t = 0.109	0.914
	Range (Min-Max)	15 (29 - 44)	19 (23 - 42)		
TOTAL PROTEIN	Mean ± SD.	5.53 ± 0.25	5.43 ± 0.23	t = 1.325	0.193
	Range (Min-Max)	1 (5 - 6)	0.8 (4.9 - 5.7)		
ALBUMIN	Mean ± SD.	4.27 ± 0.38	4.16 ± 0.29	t = 1.035	0.308
	Range (Min-Max)	1.4 (3.6 - 5)	1.1 (3.7 - 4.8)		

t: Independent T test SD: standard deviation IQR: interquartile range

p: p value for comparing between the studied groups.

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.001: Highly significant

Time to complete healing in the Contact eye solution group they were ranged from 16 to 27 with mean ± SD = 21.05 ± 3.15, while in the Povidone-iodine group, the Time to complete healing ranged from 14 to 50 with mean ± SD = 33.3 ± 8.87 with a high significant variation between both groups (p= <0.001). Hospital stays in the Contact eye solution group ranged from 10 to 17 with mean ± SD = 13.15 ± 1.98, while in the Povidone-iodine group, the Hospital stays ranged from 9 to 31 with mean ± SD = 20.65 ± 5.43 with a high significant variation between both groups (p= <0.001). Time to return to usual activity in the Contact eye solution group ranged from 18 to 30 with mean ± SD = 23.25 ± 3.48, while in the Povidone-iodine group, the Time to return to usual activity ranged from 15 to 55 with mean ± SD = 36.65 ± 9.8 with a high significant variation between both groups (p= <0.001). Daily dressing in the Contact eye solution group ranged from 1 to 2 with mean ± SD = 1.25 ± 0.44, while in the Povidone-iodine group, the Daily dressing ranged from 1 to 3 with mean ± SD = 1.75 ± 0.79 with significant variation between both groups (p= 0.019). Table 4

Table 4: Recovery timeline and Daily dressing frequency among the study groups

	CONTACT EYE SOLUTION GROUP (N = 20)	POVIDONE-IODINE GROUP (N = 20)	TEST OF SIG.	P
TIME TO COMPLETE HEALING (DAYS)			t = -5.821	<0.001
MEAN ± SD.	21.05 ± 3.15	33.3 ± 8.87		
RANGE (MIN-MAX)	11 (16 - 27)	36 (14 - 50)		
HOSPITAL STAYS (DAYS)			t = -5.801	<0.001
MEAN ± SD.	13.15 ± 1.98	20.65 ± 5.43		
RANGE (MIN-MAX)	7 (10 - 17)	22 (9 - 31)		
TIME TO RETURN TO USUAL ACTIVITY			t = -5.763	<0.001
MEAN ± SD.	23.25 ± 3.48	36.65 ± 9.8		
RANGE (MIN-MAX)	12 (18 - 30)	40 (15 - 55)		
DAILY DRESSING			t = -2.476	0.019
MEAN ± SD.	1.25 ± 0.44	1.75 ± 0.79		
RANGE (MIN-MAX)	1 (1 - 2)	2 (1 - 3)		

t: Independent T test SD: standard deviation IQR: interquartile range

p: p value for comparing between the studied groups.

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.001: Highly significant

Staining was significantly different between both groups (p= 0.017). Dermatitis was insignificantly different between both groups (p= 0.072). Table 5

Table 5. Skin-related adverse events incidence among the study groups

	CONTACT EYE SOLUTION GROUP (N = 20)	POVIDONE-IODINE GROUP (N = 20)	TEST OF SIG.	P
STAINING	0 (0%)	5 (25%)	X2 = 5.714	0.017
DERMATITIS	0 (0%)	3 (15%)	X2 = 3.243	0.072

x2: Chi- Square test p: p value for comparing between the studied groups

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.001: Highly significant

4. Discussion

Complicated interactions between the host and microbes and therapeutic and environmental interventions govern infection development. [8,9,10]

Even though inflammation is a natural reaction to injury and is necessary for healing, microbial infection can cause excessive inflammation. Chronic wounds are characterized by prolonged inflammation, inadequate remodeling of the extracellular matrix, and re-epithelialization failure.

Generally, few antibacterial agents are considered for wound treatment. Of them, povidone-iodine has remained the most widely used. [11]

Contact lens solution contains disodium edetate, boric acid, NaC1, and sodium borate. Active ingredients DYMED (polyhexamethylene biguanide) 0.00005%. Poloxamine, a 1% component, has antibacterial and antifungal effects in addition to increased proliferation of cells, migration of fibroblasts, growth factor, and gene expression levels of dermal cells. All these benefits allow us to evaluate the effect of contact lens solutions on infected wounds. [12, 13, 14]

Our main objective was the antimicrobial effect of contact eye solution on wound infection.

This is a novel trial to compare the effect of contact lens solution and Povidone-iodine on wound infection.

Contact lens solution contains disodium edetate, boric acid, NaC1, and sodium borate. Active ingredients (polyaminopropyl biguanide) 0.0001%. Poloxamine 1%. Boron compounds perform crucial functions in plant growth and are critical micronutrients for various species. However, boron is hazardous to live cells at high concentrations. Boron deficiency and toxicity are pretty close in all living creatures. Boron participates in quorum sensing, a crucial process for developing antibacterial action. Boric acid is frequently used to treat superficial wounds, ear and eye infections, and gynecological conditions. Boric acid has antibacterial, antifungal, and anticandidal properties. [15]

Gwak et al. 16 had similar findings to our trial, as they found that the Povidone iodine foam dressing group had 44.4% (16 cases) with complete wound healing at Week 8, and the foam dressing group had 44.1% (15 cases) (P = .9781). At Week 4, 22.2% in the PVP-I foam dressing group and 18% in the foam dressing group had complete wound healing (P = 0.6324). At Week 8, the two groups had a similar percentage of cases with ≥50% wound healing (foam dressing vs Povidone iodine foam dressing: 80.0% vs. 69.4%, P = 0.4030), rate of change in ulcer size (area, width, length), and mean number of days (±SD) to complete healing (33.27 ± 12.60 vs 31.00 ± 15.07 days, P = .6541).

The current study showed that the Etiology of the target ulcer was insignificantly different between groups (p= 1). Adverse events were insignificantly different between both groups (p= 0.503). Skin-related Adverse events were insignificantly different between both groups (p= 0.548).

Povidone iodine is solely intended for external usage. The common side effects of Povidone iodine are inflamed or red skin, dry skin, peeling skin, and application site irritation. These adverse effects resolve without medical intervention throughout therapy. [11]

To our results, the study of Gwak et al., [16] revealed the incidence of adverse effects of 17.1% (n = 6) in the foam dressing group and 27.8% (n = 10) in the Povidone iodine foam dressing group (P = .2836). The investigator awarded a causation assessment of "definitely not related" to all adverse effects. Most adverse effects were mild in both groups. The povidone iodine foam dressing group had 5 cases reporting 6 adverse effects (localized infection, ankle fracture, cellulitis, extremity necrosis, diabetes mellitus inadequate control, and peripheral vascular disorder). FoamThe dressing group had one case reporting one adverse effect (peripheral swelling).

Kapukaya and Ciloglu (6) reported insignificant variations in the rates of peripheral vascular disease, smoking, and diabetes between both groups (P > 0.05).

In the study of Budiman et al., [12], they reported that, with a contact period of 6 hours, the contact lens solution exhibited the maximum antibacterial activity against P. aeruginosa and S. aureus.

The present study showed no significant variation between both groups regarding laboratory measures and vital signs.

Similarly, Gwak et al., [16] reported no significant variation in vital signs, clinical laboratory findings, and physical examinations between groups.

The current trial showed that the Contact eye solution group had a significantly shorter time to complete healing than the Povidone-iodine group. Hospital stay was significantly shorter in the Contact eye solution compared to the Povidone-iodine group (p= <.001). Time to return to usual activity is significantly faster in the Contact eye solution compared to the Povidone-iodine group. Daily dressing was significantly lower in the Contact eye solution compared to the Povidone-iodine group. Daily dressing in the Contact eye solution group had a mean ± SD of 1.05 ± 0.22 with a range of 1 to 2, while in the Povidone-iodine group, the Daily dressing had a mean ± SD of 1.35 ± 0.49 with a range of 1 to 2, with significant variation between both groups (p= 0.019). The use of antibiotics was significantly different between the groups (p= 0.028).

Similarly, Budiman et al. [12] reported significant antimicrobial effects in all three contact lens solutions. Polyhexamethylene biguanide is the most prevalent active ingredient in these contact lens solutions, which launches an attack on the bacterial surface, cytoplasmic membrane, and cytoplasm. The gram-negative bacterium is subjected to more significant effects when an action on the membrane acid increases fluidity and permeability, releasing the lipopolysaccharide.

Moreover, Iguban et al., [17] stated that multipurpose solutions containing myristamidopropyl dimethylamine polyquaternium-1 and polyhexamide reduced the concentrations of fungi by 1 log and concentrations of bacteria by 3 logs, allowing them to meet the criteria for standalone disinfection solutions. At six hours post-exposure to the challenge organisms, this antibacterial efficacy peaked. Multipurpose solutions with polyquaternium-1 and myristamidopropyl dimethylamine also have the broadest effectivity against C. albicans, gram-positive and gram-negative bacteria. All evaluated multipurpose solutions had insufficient antimicrobial efficacy against F. solani.

In addition, Hinojosa et al., [18] demonstrated that each of the four tested eye lens solutions demonstrated excellent antibacterial action against every bacterial strain.

A solution for contact lenses, including polyaminopropyl biguanide and a borate buffer, has been patented. The solution is a disinfectant and preservative with a broad spectrum of fungicidal and bactericidal action at low doses. When applied to soft-type contact lenses, it has exceptionally minimal toxicity. [19]

The present study had some limitations. The main limitation is the lack of a similar previous study to compare with. Another limitation is the small sample size. It is a single-center study with a short follow-up period.

We recommended that future studies have a large enough sample size to provide meaningful conclusions and control for confounding factors. Studies should also have a longer follow-up period to accurately assess long-term outcomes. To validate our findings, future research should include multicentre studies.

5. *Conclusion*

Comparable to Povidone-iodine dressing in wound infection, contact lens solution dressing offers superior wound healing safety and efficacy.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

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