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Comparative Evaluation of Low-Level Led Light Therapy Versus Conventional Dressings in The Healing of Diabetic Foot Ulcers

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ABSTRACT

Background: Diabetic foot ulcers (DFUs) represent one of the most serious complications of diabetes mellitus and are associated with delayed wound healing, increased morbidity, and a heightened risk of lower limb amputation. Although conventional dressings constitute standard wound care, they are frequently limited by prolonged healing duration and patient discomfort. Low-level LED light therapy has emerged as a non-invasive therapeutic approach that promotes wound repair through photobiomodulation. ***Aim*:** To evaluate and compare the effectiveness of low-level LED light therapy and conventional dressings in the healing of diabetic foot ulcers. **Methods:** A comparative study was carried out among patients with diabetic foot ulcers, who were divided into a study group treated with LED light therapy and a control group managed with conventional wound care. Healing outcomes were assessed by measuring reduction in ulcer size, pain scores, and glycaemic parameters. ***Results*:** Patients treated with LED light therapy demonstrated a significantly greater reduction in ulcer size, improved granulation tissue formation, and a marked decrease in pain scores when compared to those receiving conventional dressings ($p < 0.00001$). **Conclusion:** Low-level LED light therapy is a safe, effective, and feasible treatment option that significantly enhances healing outcomes in diabetic foot ulcers.

Keywords*: Diabetic foot ulcer, LED light therapy, Low-level light therapy, Conventional dressing, Photobiomodulation.*

INTRODUCTION:

Diabetes mellitus is a rapidly growing global health concern characterized by persistent hyperglycaemia, which leads to progressive damage of multiple organ systems [1]. Among its various complications, diabetic foot ulcers are particularly disabling, contributing substantially to increased morbidity, mortality, and healthcare expenditure [2]. The development of diabetic foot ulcers is multifactorial and involves peripheral neuropathy, peripheral vascular disease, impaired immune response, and altered foot biomechanics [3]. Loss of protective sensation coupled with repetitive unnoticed trauma predisposes individuals with diabetes to chronic, non-healing ulcers [4]. It has been estimated that nearly one-fourth of diabetic patients may develop a foot ulcer at some point during their lifetime [5]. Conventional wound care practices, including regular debridement and saline or antiseptic dressings, remain the primary treatment approach. However, these methods are often associated with delayed wound healing, repeated injury to the wound surface, and considerable patient discomfort [6]. Despite advancements in wound management strategies, diabetic foot ulcers continue to show high rates of recurrence [7]. Low-level light therapy (LLLT) using LED irradiation has gained increasing attention due to its ability to stimulate cellular mechanisms involved in tissue repair. Photobiomodulation enhances mitochondrial function, increases adenosine triphosphate (ATP) production, promotes angiogenesis, and accelerates fibroblast proliferation and collagen synthesis [8,9]. Near-infrared LED light has also been shown to improve microcirculation and reduce inflammation, thereby facilitating faster wound healing [10]. Several experimental and clinical studies have reported favorable effects of LED therapy in the management of chronic wounds, including diabetic foot ulcers [11,12]. However, direct comparative evidence between LED therapy and conventional dressing methods in routine clinical practice remains limited. Hence, the present study was undertaken to compare the effectiveness of low-level LED light therapy with conventional dressings in the healing of diabetic foot ulcers.

Aim of the study: The aim of this study was to assess whether low-level LED light therapy improves ulcer healing outcomes and reduces pain when compared with conventional wound dressings in patients with diabetic foot ulcers.

MATERIALS & METHODS:

This comparative observational study was conducted in the Department of General Surgery at Karnataka Institute of Medical Sciences (KIMS), Hubballi, from November 2020 to January 2023. Patients with diabetes mellitus presenting with diabetic foot ulcers of Wagner grade I to III were included in the study. Eligible patients were allocated into study and control groups using an alternate allocation method. The nature and procedure of the respective therapies were explained in detail to all participants, and written informed consent was obtained prior to enrolment. Patients in the study group received low-level LED light therapy at a wavelength of 680 nm for one hour daily for a duration of four weeks along with saline dressing, while patients in the control group were managed with conventional wound cleaning and dressing.

Inclusion Criteria

- Patients aged 18–60 years
- Diagnosed cases of diabetes mellitus
- Presence of diabetic foot ulcer (Wagner grade I–III)
- Willingness to provide informed consent

Exclusion Criteria

- Pregnant females
- Ulcers measuring >15 cm
- Trophic ulcers
- Extensive slough over ulcer
- Malignancy
- Autoimmune diseases
- HIV, HCV, or HBsAg positive patients

Statistical Analysis

Data were represented as mean ± standard deviation, percentages, and diagrams. Quantitative variables between the study and control groups were compared using the unpaired t-test or or Mann-Whitney U test, as appropriate. Within-group comparison of quantitative variables between day 1 and day 28 was performed using the paired t-test or Wilcoxon paired signed-rank test. Qualitative variables were analysed using the Chi-square test or Fisher's exact test. A p-value of less than 0.05 was considered statistically significant.

RESULTS:

A total of 50 patients with diabetic foot ulcers were included in the study and followed up over a period of four weeks. The study was conducted between November 2020 and January 2023. Patients were randomly allocated into two equal groups, with 25 patients in the study group receiving low-level LED light therapy and 25 patients in the control group receiving conventional wound dressings. Baseline demographic and clinical characteristics were comparable between the two groups.

Table 1: Age and sex distribution among the study population

Variables		Study Group Number (%)	Control Group Number (%)
Age	<30	1 (4%)	1 (4%)
	30-39	3 (12%)	1 (4%)
	40-49	13 (52%)	14 (56%)
	50-59	4 (16%)	5 (20%)
	60+	4 (16%)	4 (16%)
Gender	Male	16 (64%)	16 (64%)
	Female	9 (36%)	9 (36%)

Table 1 shows the age and sex distribution of patients in the study and control groups. Most patients in both groups belonged to the 40–49 years age group. Male patients predominated in both the study and control groups, indicating a higher prevalence of diabetic foot ulcers among males.

Graph 1: Distribution of patients according to Cause of Wound

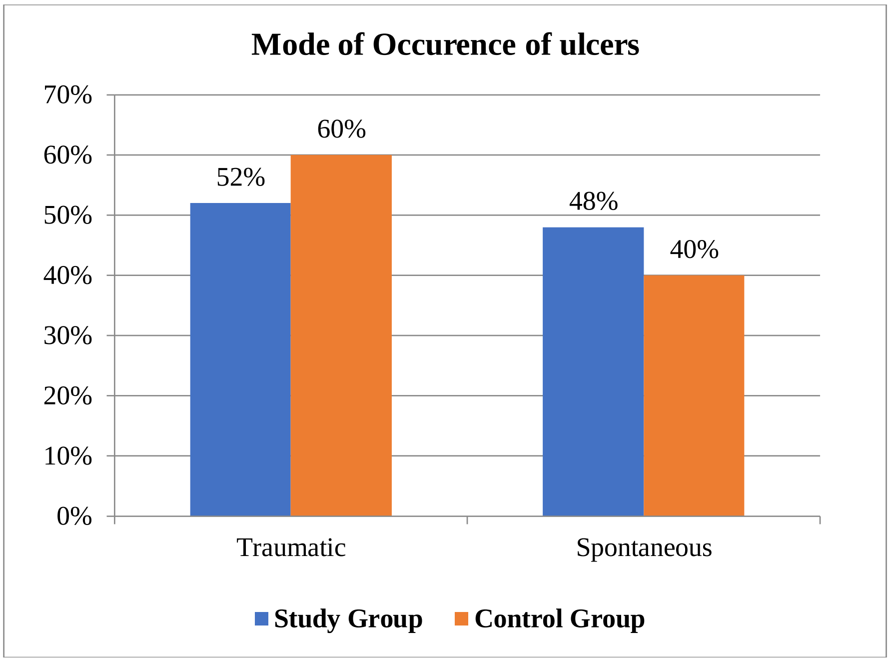

Table 2: Comparison of HbA1c (%) between study and control groups

Hba1c	Study	Control	Mean Difference	Mann U Whitney Test At P Value 0.05	P Value
Hba1c	Mean ± SD	Mean ± SD	0.208	U= 275	P Value = 0.4715
	8.088 ± 1.0286	7.88 ± 0.9571			

Table 2 compares the mean HbA1c levels between the study and control groups. The mean HbA1c values were comparable in both groups, and the difference was not statistically significant (p = 0.4715), indicating similar baseline glycaemic control.

Table 3: Culture reports of ulcers

Organism	**Study**	**Control**	**Chi Square Test**	P Value
	Number (%)	**Number (%)**		
No Growth	12**(48%)**	17 (68%)	X 2 = 7.2335	0.0648
Klesiella Oxytoca	6 (24%)	1 (4%)		
Eschericia Coli	6 (24%)	3 (12%)		
Pseudomonas Aeruginosa	1 (4%)	4 (16%)		

Table 3 presents the microbiological culture findings of the ulcers. Most ulcers showed no bacterial growth in both groups. Among culture-positive cases, Klebsiella oxytoca and Escherichia coli were the most commonly isolated organisms. The difference between the two groups was not statistically significant.

Table 4: Comparison of Age (Years) between study and control groups

	Study	Control	Mann Whitney U Test	P Value
Age (In Years)	Mean ± SD	Mean ± SD	U= 286.5	0.64
	47.2 ± 10.22	48.7 ± 9.41		

Table 4 compares the mean age of patients in the study and control groups. Although the mean age was slightly higher in the control group, the difference was not statistically significant (p = 0.64), indicating that both groups were age-matched.

Table 5: Comparison of ulcer area between 1st and 28th days in Study and control groups

	First day	28^{th} day	Mean difference	Wilcoxan signed rank test	P value
	Mean (sq.cm) ± SD	Mean (sq.cm) ± SD	In %		
Study	79.49 ± 177.32	29.704 ± 55.95	49.786	Z value =	P value

group				4.7342	<0.00001
Control group	29.93 ± 22.29	27.733 ± 22.09	2.197	Z value = 4.17	P value <0.00001

Table 5 demonstrates the change in ulcer area from day 1 to day 28 in both groups. A significant reduction in ulcer size was observed in the study group following LED light therapy ($p < 0.00001$). The control group also showed a reduction in ulcer area; however, the magnitude of reduction was significantly greater in the study group.

Table 6: Comparison of mean Visual Analog Score (VAS) between study and control group

	First day	28^{th}day	Mean differnce	Anova test	P value
	Mean VAS ± SD	Mean VAS ± SD	In %		
Study group	4.88 ± 1.42	2.64 ± 0.75	2.24	F ratio value = 53.227	<0.00001
Control group	4.36 ± 1.22	4.24 ± 1.09	3.27	F ratio value = 1.30121	0.2652

Table 6 compares pain scores between the two groups using the Visual Analog Scale. The study group showed a significant reduction in pain scores from day 1 to day 28 ($p < 0.00001$), whereas no statistically significant reduction in pain scores was observed in the control group.

DISCUSSION:

Diabetic foot ulcers remain a significant clinical challenge due to their delayed healing and high rates of recurrence [13]. In the present study, patients receiving low-level LED light therapy exhibited faster wound healing and greater pain reduction compared to those treated with conventional dressings. The therapeutic benefits of LED light therapy are primarily attributed to photobiomodulation, which activates mitochondrial respiratory chain enzymes, resulting in increased ATP production and enhanced cellular metabolism [14]. These effects promote fibroblast proliferation, collagen synthesis, and angiogenesis, which are essential processes in wound healing [15]. Previous studies have similarly demonstrated that LED or low-level laser therapy accelerates granulation tissue formation and epithelialization in chronic wounds [16,17]. Salvi et al. reported improved vascular and neural responses following near-infrared LED therapy, further supporting its effectiveness in diabetic wound management [18]. The significant reduction in pain observed among patients receiving LED therapy may be related to decreased inflammatory mediator release and improved microcirculation, leading to reduced tissue ischemia [19]. In contrast, conventional dressings, although useful in maintaining a moist wound environment, may result in repeated mechanical trauma and discomfort due to frequent dressing changes [20]. The findings of the present study add to the growing body of evidence supporting LED light therapy as an effective adjunct or alternative to conventional wound care. Its non-invasive nature, simplicity of application, and cost-effectiveness make it particularly suitable for use in resource-limited healthcare settings [21].

CONCLUSION:

Low-level LED light therapy significantly improves healing outcomes in diabetic foot ulcers compared to conventional dressings. It accelerates ulcer size reduction, reduces pain, and enhances granulation tissue formation. LED therapy is a safe, feasible, and effective modality that can be incorporated into routine management of diabetic foot ulcers.

Declaration:

Conflicts of interests: The authors declare no conflicts of interest.
Author contribution: All authors have contributed in the manuscript.
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