

## Polarized Light Therapy for Wounds: A Systematic Review

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### ABSTRACT

**Background:** Wounds have a variety of types. Impairment of healing is a common adverse event of wounds. The degree of tissue injury caused by burn wounds and ulcers can lead to further pain and disability. Polarized light therapy (PLT) has the ability to penetrate the skin up to 5 cm deep, reaching deeper tissues that are necessary for wound healing.

**Objective:** This article aimed to systematically review the reported randomized control trials (RCTs) as regards PLT effects in treatment of wounds.

**Methods:** An electronic search was conducted in Cochrane library, Physiotherapy evidence database (PEDro) and PubMed database. The research comprised RCTs published at the period from 2019 to 2023 only on PLT effects in treatment of wounds of burned and ulcerated patients. In addition, 2 independent reviewers extracted data from the comprised researches and evaluated its methodological quality by utilizing PEDro scale.

**Results:** Eight studies matched the inclusion criteria. They provided limited to strong level to support the efficiency of PLT based on modified Sackett's scale. Meta-analysis was done for four included studies only and showed a significant difference between the PLT and control groups and revealed significant decrease in ulcer surface area (USA) in PLT group. As a result, it revealed significant effect of PLT on ulcer healing.

**Conclusion:** This systematic review revealed limited to strong evidence. It supported the effectiveness of PLT in treatment of wounds (ulcers, burns and wounds).

**Keywords:** Wound, Ulcer, Burn, Healing, Polarized light therapy, Bioptron.

### INTRODUCTION

Chronic wounds have an impact on one's quality of life (QoL) and the treatment of wounds has also considerable economic burdens on healthcare. Owing to the geriatric subjects, the persistent threat of diabetic and overweight patients all over the world, and the persistent problem of infections, it is expected that chronic wounds could remain to be a considerable clinical, social, and economic challenge. A chronic non-healing wound (CNHW) is associated with comorbidities such as diabetes mellitus, vascular insufficiency, hypertension and renal dysfunction. Such predisposing factors make subjects with CNHW at high possibility for worse prognosis <sup>(1)</sup>.

Skin ulceration represents a difficult clinical problem and has been considered as a main source of morbimortality for cases. Pain, swelling and wound drainage have significant effects on the patient's QoL. Local infections, colonization and systemic manifestations add to the morbidity and have been demonstrated to be accompanied by amputation with a higher death rate <sup>(2)</sup>.

Interestingly, extensive burns could have prolonged impacts on QoL, which include scar formation, contractures, weakness, pruritus, pain and psychiatric wellbeing. Moreover, the critical care management could be associated with cognitive, affective or behavioral challenges. Reliably, subjects with burns reported a lot of restrictions in their QoL in comparison with free normal ones <sup>(3, 4)</sup>.

Wound healing has been considered as a complicated process where the skin and organs repair themselves following injuries. Essentially, wound healing is a dynamic process featured by interactions of different cell types, which include lymphocytes, monocytes and fibroblasts. Inflammation, granulation tissue development and proliferation are recognized as three major overlapping processes in tissue response to injury <sup>(5)</sup>.

Polarized light has been considered as a system, which generates light with polarization, incoherency, low energy and polychromacy. Polarized light waves oscillate on parallel planes. Linear divergence across reflection is of great efficacy and has a degree of polarization of about 95%. The system of PLT covers a wavelength range of 480 nm to 3400 nm, that comprises visible light and some infrared radiation (the polarized light electromagnetic spectrum doesn't include UVR). Bioptron is incoherent or "out-of-phase," meaning the light waves aren't synchronized <sup>(6)</sup>.

PLT had positive biologic actions as regards improving healing across enhancement of the cell membrane functions, rising the frequency of mitochondrial ATP formation. In addition, it decreased inflammation, improved microcirculation, tissue oxygenation, improved new blood vessel formation to the affected area, fibroblast proliferation, composition of collagen and enhanced epithelialization. Owing to the improvement of such functions, this approach was talented to improve wound healing process. As a result, it is significantly important to systematically review the

published RCTs as regards the effects of PLT in wound healing <sup>(7, 8)</sup>.

## MATERIALS AND METHODS

This systematic review recorded according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement <sup>(9)</sup>. The protocol of this study prospectively registered and approved from Faculty of Physical Therapy, Cairo University, No:P.T.REC/012/004645.

This review was conducted through electronic database and manual search, lastly updated in October 2023, to provide valid evidence regarding the efficiency of PLT in wound management and it followed the following steps:

**1. Eligibility criteria:** Articles were comprised if they were randomized controlled trials comparing polarized light therapy (Biopton) with control, placebo, or standard care, as well as comparison with alternative physical therapy modality in treating adult patients with different types of wounds (burn and skin wound). Further, articles were eligible if they measured improvement of wound healing. Search was limited to RCTs only that published from 2019 to October 2023, articles were ruled out if they weren't of RCT study design, not on humans and the articles published in non-English language.

### 2. Searching strategy:

Electronic database was done in:

- The Cochrane Library at <http://www.thecochranelibrary.com>.
- PubMed at <https://pubmed.ncbi.nlm.nih.gov/>
- PEDro at <http://www.pedro.org.au/>.
- Google scholar at <https://scholar.google.com/>

The next keywords and Boolean operators were employed: "Polarized light therapy" OR Biopton AND Wound OR Burn OR Ulcer AND Healing. All databases were searched from the inception till October 2023.

**3. Study selection:** Two independent reviewers checked studies for eligibility against inclusion and exclusion criteria, after removing duplicates by EndNote 20; reference management software <sup>(10)</sup>, first by title then by abstract and finally by reading the full text. Manual search was done by checking the reference lists of relevant publications.

**4. Data extraction:** Data were extracted from the comprised researches by a single reviewer and cross-checked by a 2<sup>nd</sup> reviewer. Data extraction form comprised of authors and year of publication, participants, intervention, outcomes measurement and authors' conclusion.

**5. Methodological quality assessment:** The quality of eligible researches was evaluated by 2 independent investigators, with any confliction resolved by a 3<sup>rd</sup> investigator using physical therapy evidence database scale (PEDro) scale <sup>(11)</sup>. In terms of rating methodological quality, the next classification was utilized: PEDro score less than four denoted poor, 4-5 fair, 6-8 good and 9-10 excellent. The modified Sackett' scale was utilized to evaluate the evidence level <sup>(12)</sup>.

### 6. Data Synthesis and Analysis:

According to treatment and outcomes homogeneity in some studies, a meta-analysis was conducted to compare the effects of polarized light therapy against standard care or other treatment as measured by ulcer surface area. The researches were analysed by utilizing Review Manager software (London, UK) and Microsoft Excel 2010. In the context of effective measure, MD and 95% CI were utilized for the same outcome measures among researches. In the current study, we conducted an exploration and quantification between-study statistical heterogeneity by utilizing the I<sup>2</sup> test. The fixed effect model was utilized in whole analyses, in cases when heterogeneity was significant ( $p < 0.05$ ) or I<sup>2</sup> was more than 50%, we utilized random-effects model instead<sup>(13)</sup>. The other included studies that were clinically heterogeneous in regards to the outcomes measured, descriptive analysis was used to present its data <sup>(14)</sup>, and the overall level of evidence for each intervention, which was specified based on the modified Sackett's scale <sup>(12)</sup>.

## RESULTS

**1. Search Results:** The search identified 105 trials from 2019 to October 2023. 9 of them were duplicated, 56 marked as ineligible by automation tools, 40 records were screened; 31 of them were ruled out following screening titles and abstracts and 1 article were ruled out after reading the full text. The included articles were 8 RCTs, which appeared to meet the eligibility criteria had been assessed. Search outcomes were presented according to the PRISMA flow chart <sup>(9)</sup> (Figure 1).

**2. Sample Size and Participants:** The 8 studies [Ali *et al.* <sup>(15)</sup>, Taha *et al.* <sup>(16)</sup>, Ashem *et al.* <sup>(17)</sup>, Mohamed *et al.* <sup>(18)</sup>, Mowafy *et al.* <sup>(19)</sup>, Mowafy *et al.* <sup>(20)</sup>, Elattar *et al.* <sup>(21)</sup> and El Sayed <sup>(22)</sup>] included a total of 320 participants with ages ranged from 25 to 75 years. The sample size ranged from 30 to 60, description of patients characteristics in addition to intervention and outcome measurement and authors' conclusion are displayed for each type of wound reviewed in tables (1, 2 & 3).

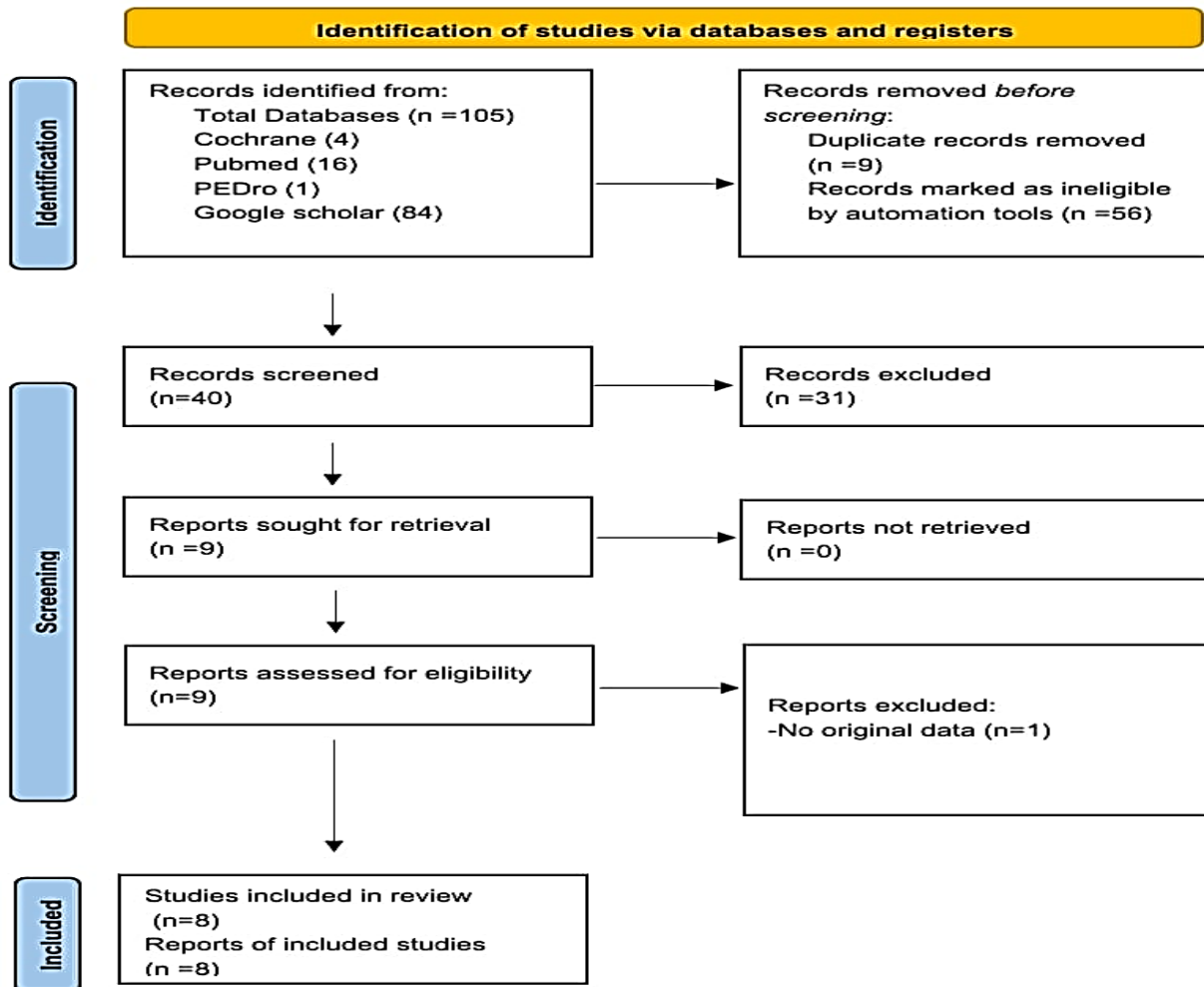


Figure (1): The PRISMA flow chart of the included studies.

**3. Effects of interventions:**

For Ulcers, four studies [Ali *et al.* <sup>(15)</sup>, Taha *et al.* <sup>(16)</sup>, Ashem *et al.* <sup>(17)</sup> and Mohamed *et al.* <sup>(18)</sup>] compared polarized light therapy with standard ulcer care or other treatment. They reported significant difference between-groups in ulcer surface area reduction and healing. One study by Mohamed *et al.* <sup>(18)</sup> compared PLT with shock wave. Again significant difference between-groups was reported regarding ulcer healing. Another study by Ali *et al.* <sup>(15)</sup> compared PLT and law intensity laser therapy (LILT) and reported no significant difference in ulcer healing between-groups.

**Burn:** The two researches by Mowafy *et al.* <sup>(19)</sup> and Mowafy *et al.* <sup>(20)</sup> compared between PLT with LLLT in adult patients with burn. Collectively included seventy patients diagnosed with partial thickness thermal burn aged from 25 to 35 years were randomized to BLT or LLLT group. BSA and CC measurement were compared between groups; both studies concluded that the PLT and the Ga-As laser were efficient in improving healing of burns, as manifested by the highly reduces BSA and CC. The study by Mowafy *et al.* <sup>(19)</sup> revealed that LLLT was more efficient and advantageous compared to the BLT in reducing the CC, indicating that LLLT was more bactericidal, while the study of Mowafy *et al.* <sup>(20)</sup> revealed that BLT was more

effective than LLLT in the enhancement of the burned wounds healing. **Wound:** Elattar *et al.* <sup>(21)</sup> compared the effects of NPWT versus PLT on chronic wound healing. Thirty patients diagnosed as chronic wound patients (grade II and III) aged from 45 to 65 years. Sessions were three times a week with the conventional medical therapy for six weeks. Comparison between the two groups post-treatment demonstrated a non-significant difference in wound SA and wound volume at post I ( $p>0.05$ ). On the other hand, there were a significant reduction in wound SA ( $p=0.02$ ) and wound volume ( $p=0.01$ ) of NPT group in comparison with that of PLT group at post II. It was recommended that NPWT was of great efficacy in comparison with PLT on decreasing wound SA and wound volume in chronic wounds. In addition, 30 cases with various wound types were contributed to the research by El Sayed <sup>(22)</sup>. He investigated the effectiveness of hyperpolarized light therapy and conventional wound care versus conventional wound care only. Significant improvement in the wound healing process following 4 weeks of management by hyperpolarized light therapy. He concluded that the effects of hyperpolarized light for various wounds were acceptable. As a result it is of great importance to apply hyperpolarized light in the management of various wound kinds.

Table (1): Characteristics of included studies involving healing of ulcers.

Author (Year)	Participants	Intervention	Outcome Measurement	Authors' conclusion
<b>Ali et al. 2022.</b>	<ul style="list-style-type: none"> <li>▪ N=45</li> <li>▪ SG1=15</li> <li>▪ SG2 =15</li> <li>▪ CG =15</li> <li>▪ Age range = 45-55 years</li> <li>▪ Inpatient with venous leg ulcers just above medial malleolus</li> </ul>	<ul style="list-style-type: none"> <li>▪ SG1=polarized light therapy</li> <li>▪ SG2=low intensity laser (LILT)</li> <li>▪ Both + the regular ulcer care</li> <li>▪ CG= the regular ulcer care only</li> </ul>	<ul style="list-style-type: none"> <li>▪ USA</li> <li>▪ CC</li> </ul>	The PLT and the LILT were efficient as regards the improvement of venous ulcer healing, however the PLT was of great efficiency in reducing ulcer SA and colony count (CC) and the improvement of the healing of venous ulcers compared to the LILT
<b>Taha et al. 2021.</b>	<ul style="list-style-type: none"> <li>▪ N=40</li> <li>▪ SG =20</li> <li>▪ CG =20</li> <li>▪ Age range = 50-70 years</li> <li>▪ Type 2 diabetes mellitus with Wagner grade I or 2 DFUs</li> </ul>	<ul style="list-style-type: none"> <li>▪ SG= Bioptron light therapy (2.4 J/cm<sup>2</sup>, Wavelength 480–3400 nm)12min-3times/w +standard wound care</li> <li>▪ CG= standard wound care only</li> <li>▪ For 2-months</li> </ul>	<ul style="list-style-type: none"> <li>▪ USA, length, and width= the ruler technique.</li> <li>▪ WV= the saline-filled ulcer</li> <li>▪ Microbial cultures and identification of microorganisms = Bacterial isolation and identification</li> </ul>	PLT appears to be an efficient treatment modality in association with traditional care in the reduction of wound size and the reduction of ulcer microbiota for DFUs. It decreased ulcer bacterial infections with a subsequent enhancement of its healing.
<b>Ashem et al. 2020.</b>	<ul style="list-style-type: none"> <li>▪ N=60</li> <li>▪ SG =30</li> <li>▪ CG =30</li> <li>▪ Age range = 65-75 years</li> <li>▪ Pressure ulcers (grade II and III)</li> </ul>	<ul style="list-style-type: none"> <li>▪ SG=polarized light (wavelength 480-3400nm, 2.4 J/cm<sup>2</sup>) 3times/w.</li> <li>▪ CG= vacuum assisted closure (VAC) therapy(125 mmHg) daily</li> <li>▪ Both for 2 months.</li> </ul>	<ul style="list-style-type: none"> <li>▪ USA = digital photography</li> <li>▪ Ulcer depth = tipped cotton applicator method.</li> <li>▪ Wound culture</li> </ul>	PLT and VAC had considerable effects on pressure ulcers healing with high considerable improvements in ulcer SA and depth by utilizing PLT in comparison to VAC. In addition, the effects are positive on wound culture by utilizing the two modalities
<b>Mohamed et al. 2019.</b>	<ul style="list-style-type: none"> <li>▪ N=45</li> <li>▪ SG1 =15</li> <li>▪ SG2=15</li> <li>▪ CG =15</li> <li>▪ Age range = 55-65 years</li> <li>▪ Diabetic patients with chronic foot ulcer (Grade 2) and surface area wide is more than 1 cm<sup>2</sup>.</li> </ul>	<ul style="list-style-type: none"> <li>▪ SG1= polarized light therapy (wavelength 480-3400nm, 2.4 J/cm<sup>2</sup>) 3times/w.</li> <li>▪ SG2= shock wave (500 P/1cm<sup>2</sup> + 0.1 mJ/mm<sup>2</sup> density) once/w.</li> <li>▪ Both plus traditional wound care</li> <li>▪ CG= traditional wound care only.</li> <li>▪ For 2 months.</li> </ul>	<ul style="list-style-type: none"> <li>▪ USA=The planimeter method</li> <li>▪ Enzyme-linked Immunosorbent Assay (ELISA)= Blood sample test</li> </ul>	PLT and shock wave therapy (SWT) were effective in increasing the healing of diabetic foot ulcer (DFU) and lowering of IL-6, but PLT was more effective compared to SWT in increasing the healing of DFU and reducing of IL-6.

CC: colony count, CG: control group, DFUs: diabetic foot ulcers, IL-6: Interleukin-6 N: number, SC: study group, USA: ulcer surface area, WV: wound volume.

**Table (2):** Characteristics of included studies involving healing of burn.

Author (Year)	Participants	Intervention	Outcome Measurement	Authors' conclusion
Mowafy <i>et al.</i> 2022.	<ul style="list-style-type: none"> <li>▪ N=40</li> <li>▪ SG =20</li> <li>▪ CG =20</li> <li>▪ Age range= 25-35 years</li> <li>▪ partial thickness thermal burn affecting foot + TBSA 1% to 5%.</li> </ul>	<ul style="list-style-type: none"> <li>▪ SG= the BLT</li> <li>▪ CG= the LLLT</li> <li>▪ Both together with traditional physical therapy routine and conventional management of the burns wounds.</li> <li>▪ 10 min /daily 3times/w for 1 month or until wound healing</li> </ul>	<ul style="list-style-type: none"> <li>▪ BSA= planimeter method</li> <li>▪ CC =A sterile cotton swab.</li> </ul>	The two PLT and the Ga-As laser were efficient in improving healing of burns as presented by the high reduction in both BSA and CC. On the other hand LLLT was very efficient compared to the PLT in reducing the CC denoting that LLLT was more bactericidal.
Mowafy <i>et al.</i> 2021.	<ul style="list-style-type: none"> <li>▪ N=30</li> <li>▪ SG =15</li> <li>▪ CG =15</li> <li>▪ Age range= 25-35 years</li> <li>▪ partial thickness thermal burn on the forearm</li> </ul>	<ul style="list-style-type: none"> <li>▪ SG= BLT</li> <li>▪ CG= LLLT</li> <li>▪ Both + traditional physical therapy routine and Traditional treatment for the burn wound.</li> <li>▪ 3times /w for 30 days</li> </ul>	<ul style="list-style-type: none"> <li>▪ BSA</li> <li>▪ CC</li> <li>Both by the planimeter method</li> </ul>	PLT and LILT had a great efficacy in terms of wound healing management, on the other hand PLT was of great efficacy as regards the improvement of the burned wounds healing

BLT: bioptron light therapy, BSA: burn surface area, CC: colony count, CG: control group, Ga-As: gallium arsenide, LLLT: low level laser therapy, N: number, SC: study group.

**Table (3):** Characteristics of included studies involving wound healing.

Author (Year)	Participants	Intervention	Outcome Measurement	Authors' conclusion
Elattar <i>et al.</i> 2021.	<ul style="list-style-type: none"> <li>▪ N=30</li> <li>▪ SG =15</li> <li>▪ CG =15</li> <li>▪ Age range= 45-65 years</li> <li>▪ Chronic wound patients (grade 1 &amp;2)</li> </ul>	<ul style="list-style-type: none"> <li>▪ SG= PLT (2.4j/cm<sup>2</sup>) 10 min– 3 times/w</li> <li>▪ CG =NPT daily (125mmHg) with dressings changes three times/w.</li> <li>▪ Both with the conventional medical therapy for six weeks.</li> </ul>	<ul style="list-style-type: none"> <li>▪ WSA= tracing method</li> <li>▪ WV=saline</li> </ul>	Negative pressure therapy (NPWT) was more effective than PLT on decreasing wound SA and wound volume in chronic wounds.
El Sayed 2021.	<ul style="list-style-type: none"> <li>▪ N=30</li> <li>▪ SG =15</li> <li>▪ CG =15</li> <li>▪ Age range= 45-50 years</li> <li>▪ with different wound injuries (2<sup>nd</sup> to 3<sup>rd</sup> degree)</li> </ul>	<ul style="list-style-type: none"> <li>▪ SG=Hyperpolarized light (Biopton light) wavelength: 400–2000 nm. 3times/w + traditional wound care</li> <li>▪ CG= traditional wound care only</li> <li>▪ Both for 1 month</li> </ul>	<ul style="list-style-type: none"> <li>▪ Wound Assessment = BATES-JENSEN WOUND ASSESSMENT TOOL (BWAT).</li> </ul>	The effect of hyperpolarized light in terms of various kinds of wound were satisfactory. Following 4 weeks of treatment, 15 cases with various wound kinds demonstrated a considerable improvement in the wound healing process, as a result it may be helpful to apply hyperpolarized light in the treatment of various wound kinds.

CC: colony count, CG: control group, N, number, NPWT: negative pressure wound therapy, PLT: polarized light therapy, SC: study group, WSA: wound surface area, WV: wound volume.

#### 4. Quality of the comprised researches:

The methodological quality of comprised researches is presented in table (4). The quality of researches ranged from good [4 studies; **Taha et al.** <sup>(16)</sup>, **Ashem et al.** <sup>(17)</sup>, **Mohamed et al.** <sup>(18)</sup> and **El Sayed** <sup>(22)</sup>] to fair [4 studies; **Ali et al.** <sup>(15)</sup>, **Mowafy et al.** <sup>(19)</sup>, **Mowafy et al.** <sup>(20)</sup> and **Elattar et al.** <sup>(21)</sup>] with a mean PEDro score of 6 out of 8. Based on PEDro scale all included studies in this review; participants were allocated randomly, acquired one or more outcomes from more than 85% of the initially allocated members, recorded outcomes of between-groups statistical comparisons and offered measures of variability for one

or more outcomes, specified the eligibility criteria and had groups of similar baselines. Studies by **Taha et al.** <sup>(16)</sup>, **Ashem et al.** <sup>(17)</sup>, **Mohamed et al.** <sup>(18)</sup> and **El Sayed** <sup>(22)</sup> had blinded participants, one study by **Ashem et al.** <sup>(17)</sup> had concealed allocation and two studies by **Taha et al.** <sup>(16)</sup> and **Ashem et al.** <sup>(17)</sup> had blind assessors. None of studies had blind therapists that could be related to the type of intervention used, which did not allow blinding in most of the studies. Only one study of **Taha et al.** <sup>(16)</sup> conducted an intention-to-treat analysis.

**Table (4):** Methodology assessment of included studies according to PEDro scale

Study	1*	2	3	4	5	6	7	8	9	10	11	Total (0-10)	Quality
<b>Ali et al. 2022.</b>	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5	Fair
<b>Taha et al. 2021.</b>	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	8	Good
<b>Ashem et al. 2020.</b>	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	8	Good
<b>Mohamed et al. 2019.</b>	Y	Y	N	Y	Y	N	N	Y	N	Y	Y	6	Good
<b>Mowafy et al, 2022.</b>	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5	Fair
<b>Mowafy et al. 2021.</b>	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5	Fair
<b>Elattar et al. 2021.</b>	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5	Fair
<b>El Sayed 2021.</b>	Y	Y	N	Y	Y	N	N	Y	N	Y	Y	6	Good

\* This criterion is not counted for the total PEDro score

In table (5), based on the modified Sackett's scale, the PLT level of evidence was classified according to the type of wound.

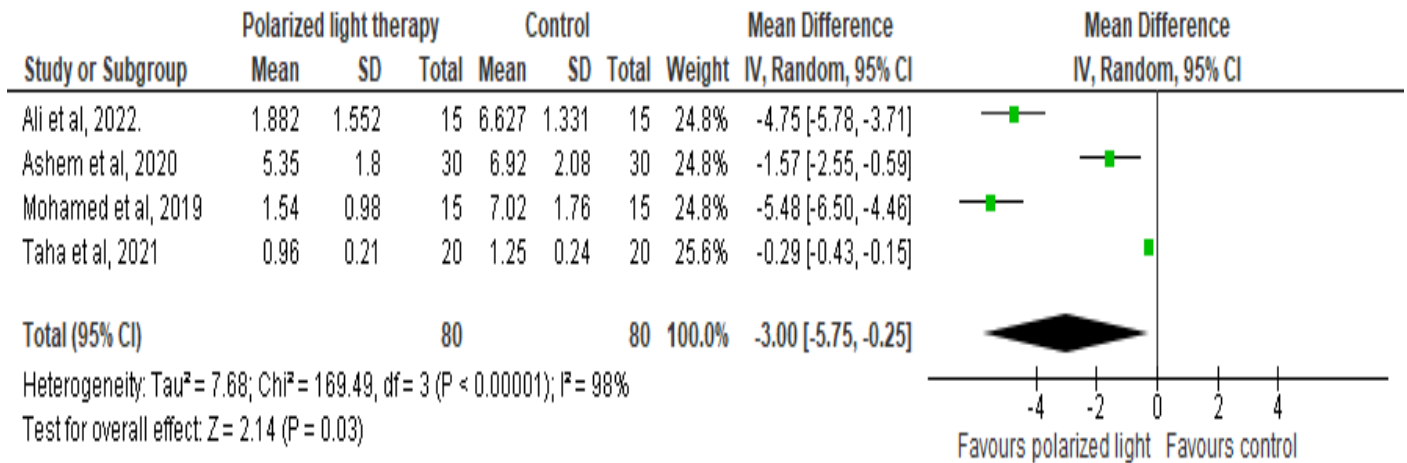
**Table (5):** Quality and level of evidence regarding PLT

Type	Included study	PEDro score= Quality	Level of Evidence
Ulcers	<b>Ali et al. (2022)</b>	5= Fair	Level 1a (Strong)
	<b>Taha et al. (2021)</b>	8= Good	
	<b>Ashem et al. (2020)</b>	8= Good	
	<b>Mohamed et al. (2019)</b>	6= Good	
Burn	<b>Mowafy et al. (2022)</b>	5= Fair	Level 2a (Limited)
	<b>Mowafy et al. (2021)</b>	5= Fair	
Wounds	<b>Elattar et al. (2021)</b>	5= Fair	Level 1b (Moderate)
	<b>El Sayed (2021)</b>	6= Good	

## 5. Meta –Analysis

**1) Comparison between PLT and control groups:**

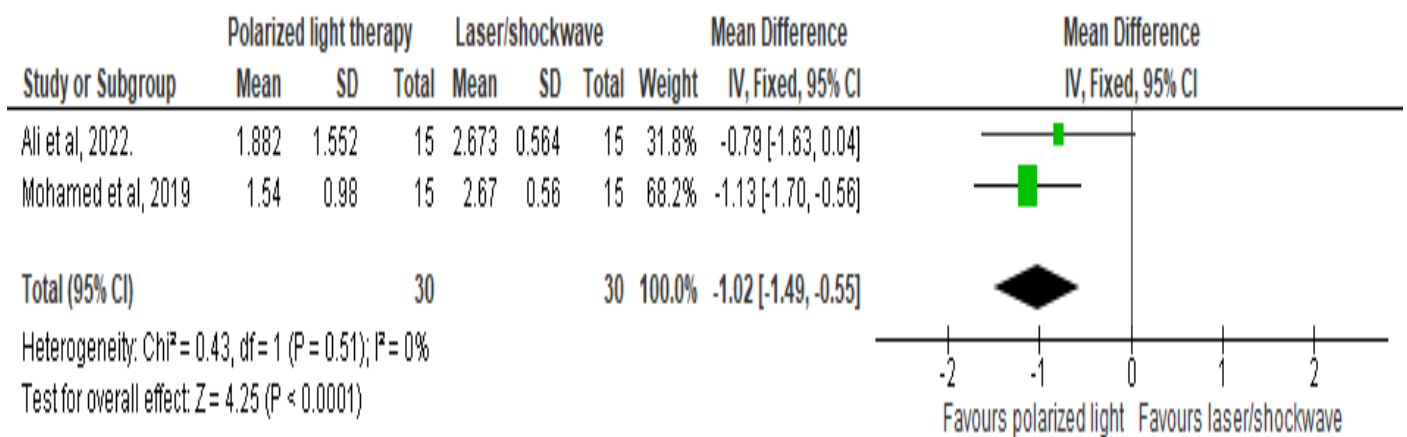
Including 4 studies in a pooled analysis in USA in ulcer healing (15-18), we performed an analysis of change scores between pre-and post-assessment. The 95% CI of the overall effect estimate (MD= -3.00; 95% CI= -5.75, -0.25; the overall effect p=0.03; I<sup>2</sup>=98%; random-effects model) did not overlap the null effect value and on its left side (favours to polarized light therapy). The meta-analysis showed a significant difference between the polarized light and controls and revealed significant decrease in ulcer surface area in PLT group. As a result, there was significant effect of PLT on ulcer healing. The I<sup>2</sup> statistic indicated high heterogeneity between the studies (I<sup>2</sup> = 98%, P < 0.00001, random-effects model) (Figure 2).



**Figure (2):** Forest plot of comparison: 1 comparison between polarized light therapy and control outcome: 1.1 Ulcer surface area.

**2) Comparison between polarized light therapy and laser/shockwave groups:**

Two studies were used in a pooled analysis on USA in ulcer healing (15, 18) we performed an analysis of change scores between pre-and post-assessment. The 95% CI of the overall effect estimate (MD= -1.02; 95% CI= -1.49, -0.55; the overall effect p= 0.0001; I<sup>2</sup>= 0%, fixed-effects model) did not overlap the null effect value on its left side (favours to PLT groups). The meta-analysis showed a significant difference between the PLT group and laser/shockwave group and revealed a significant decrease in ulcer surface area in PLT groups and revealed a significant effect of PLT on ulcer healing. The I<sup>2</sup> statistic (I<sup>2</sup>=0%, P=0.51, fixed-effects model) showed zero heterogeneity between studies indicating their suitability to be pooled into meta-analysis (Figure 3).



**Figure (3):** Forest plot of comparison: 2 comparison between polarized light therapy and laser/shockwave, outcome: 2.1 Ulcer surface area

## DISCUSSION

The current systematic review (SR) aimed to find and summarize the evidence on the efficiency of polarized light therapy on healing of burns, wounds and ulcers. Systematic methods were used for search and evaluation of the available relevant studies. Such SR demonstrated limited to strong evidence on the effectiveness of polarized light therapy on healing of ulcers, burns and wounds; as the effects of PLT on healing of ulcers were of strong evidence, while on burns were of limited evidence and on wounds were moderate evidence.

The search of the current SR revealed a number of studies that investigated the effect of PLT on healing of ulcers, burns and wounds; eight RCTs were included, with a total of 320 patients. Electronic database used were Cochrane library (CENTRAL), which is a collection of databases that comprise high-quality and independent evidence to notify healthcare decision-making, PEDro; designed to support the practice of evidence-based physiotherapy, PubMed (MEDLINE) database and Google Scholar. The primary causes for exclusion of the other studies were that they didn't meet the inclusion criteria of this systematic review as review articles and studies measured irrelevant outcomes.

This SR was conducted according to PRISMA 2020 guideline, which indicated advances in approaches to recognize, choose, appraise, and synthesize researches<sup>(9)</sup>. The internal validity of the comprised researches were assessed through the PEDro scale criteria of proper randomizations, allocation concealment, blinding of members, therapists and research personnel, partial outcome data, baseline similarity and usage of intention to manage analysis<sup>(23)</sup>.

Analyzing data and interpreting outcomes of a SR and/or meta-analysis could be intimidating at first owing to the sheer volume of data. If researches are very heterogeneous, it might be very suitable to summarize the data narratively and not attempt a statistical summary. Quantitative researches of identical quality and methodology could be analysed, compared and combined by utilizing the tools of meta-analysis<sup>(24)</sup>.

The current review used systematic approaches to recognize, critically appraise related research, to gather and analyze data from the included studies in the review. **Shah et al.**<sup>(25)</sup> reported that Meta-analysis is a formal systematic method and quantitative analysis of a lot of current researches to synthesize advanced research outcomes based on the current data. Only four studies<sup>(15, 16, 17, 18)</sup> of the eight included RCTs in this review were homogenous and their data were quantitatively analysed.

Meta-analysis was done for the effects of PLT on ulcer healing (USA) in ulcerated patient. The meta-analysis showed a significant difference between the polarized light and controls and revealed significant reduction in ulcer SA in PLT group. The other included studies were clinically heterogeneous with regard to the interventions utilized and the outcomes measured,

therefore descriptive analysis was used to present its data and the overall level of evidence for each intervention, which was specified based on the modified Sackett's scale<sup>(12)</sup>.

The recent review by **Allam et al.**<sup>(26)</sup> collected information about PLT for treatment of various kinds of wounds (burns, infected & surgical wounds and ulcers) to investigate wound healing in animals and humans. They concluded that PLT could be utilized as complementary therapy for treatment of various types of wound, but this review did not follow systematic methods.

The included studies in this review regarding ulcers, revealed strong evidence on the efficiency of PLT in healing of ulcers. The parameters of PLT were (wavelength 480-3400 nm, 2.4 J/cm<sup>2</sup>), the treatment sessions were conducted 3 times weekly for 2 months. Authors of the included studies justified that polarized light therapy is progressively successful in accelerating the healing of DFU and reduction of IL-6 level across the stimulation of regenerative processes and anti-inflammatory effect in the study conducted by **Mohamed et al.**<sup>(18)</sup>. The study by **Taha et al.**<sup>(16)</sup> suggested that diabetic patients with Wagner grade 1 or 2 DFUs can enhance their ulcer healing and immune system through reducing wound size and reducing ulcer microbiota by PLT that enhances healing and decreases microbial infection in DFUs.

**Ashem et al.**<sup>(17)</sup> indicated that pressure ulcers were healing with a considerable improvement in ulcer SA and depth using polarized light. **Ali et al.**<sup>(15)</sup> have demonstrated that the PLT is successful in the reduction of ulcer SA and CC and improving the healing of venous ulcer.

The included studies in this review regarding burn revealed limited evidence on the efficiency of PLT in healing of burn. Treatment duration of BLT was about 10 minutes for each session, one time per day, three times every week for 28 days or till healing happens. Both researches by **Mowafy et al.**<sup>(19)</sup> and **Mowafy et al.**<sup>(20)</sup> provide limited evidence that polarized light therapy was efficient in improving healing of burn, as presented by the great reductions in both BSA and CC. The study findings by **Mowafy et al.**<sup>(19)</sup> revealed that LLLT was of great efficiency in comparison with the BLT as regards the reduction in the CC, denoting that LLLT was more bactericidal, while the study by **Mowafy et al.**<sup>(20)</sup> revealed that BLT is more effective than LLLT as regards the accelerations of the wound healing in burn.

The comprised researches in the current review regarding wounds, revealed moderate evidence on the effectiveness of PLT in wound healing. Specialized characteristics of hyperpolarized light were used: (wavelength: 400-2000nm, light vitality: 2.4 J/cm<sup>2</sup>) for 1 month, 3 times per week. **El Sayed**<sup>(21)</sup> results on effects of hyperpolarized light in the context of various types of wound were acceptable. Patients with different wounds demonstrated a considerable improvement as



regards wound healing. It is considered that hyperpolarized light induced modifications of the lipid bilayer in the cell membranes and stimulated human cellular and humoral guards. As a result it may be helpful to apply hyperpolarized light in the context of wound management. According to the scope and outcomes of the study by **Elattar et al.** (22) on chronic wound cases (grade II and III). Applying PLT for about 10 minutes, three times weekly for six weeks provides evidence that PLT is effective on reduction of wound SA and wound volume in chronic wounds. Practically, the next parameters are suggested by **Taradaj** (27) a treatment duration of ten minutes (that must be correlated with the size of the SA and required to be adjusted separately), wavelength of 480–3400 nm, beam polarization of 95%, power density of 40mW/cm<sup>2</sup>, and dosage/energy density of 2.4J/cm<sup>2</sup>.48.

Previous published SR by **Nicolaou et al.** (28) searched articles in the years 2002-2019 to investigate the effects of PLT on musculoskeletal system, skin, and burn. The methodological quality of such researches was evaluated by utilizing the twelve quality assessment criteria of all RCTs by **Furlan et al.** (29) that included 5 articles in dermatological and ulcer treatment. It did not give clear evidence in its conclusions, it reviewed study by Medenica and revealed that it significantly decreased the diameter of a wound from an ulcer, although there are even records that it might be of great advantages over healing effects of laser therapy.

This systematic review had many strength points including collection of the evidence regarding PLT for different types of wounds for enhancement and improvement of healing. It included only RCT design, which is the gold standard primary study design for systematic review (30). The included studies in this systematic review had a mean PEDro score of 6, which is a good quality and overall strong evidence that was rated based on the modified Sackett's scale. In addition, having descriptive analysis as well as meta-analysis.

The main limitation in our SR was the small number of comprised RCTs for each type of wounds and the difference in its measurement. Future directions for more well designed RCTs into the effects of PLT on different outcomes as scar formation and QoL in addition to wound SA, wound volume and microbial cultures. Although the current SR collected the effects of PLT for various kinds of wounds where the results of the current SR require to be interpreted in a cautious manner as regards limited number of RCTs and the relatively small sample size in some trials.

## CONCLUSION

The current systematic review demonstrated limited to strong evidence on the efficiency of PLT in improving healing in different types of wounds (ulcers, burns and skin wounds). The meta-analysis showed a significant difference between the PLT and the controls.

It revealed significant decrease in ulcer SA and promoted healing in PLT group. In conclusion, the present evidence supports that polarized light therapy could be an effective intervention in improving ulcers, burns and wounds healing. More randomized controlled trials with larger samples size are needed to improve the current evidence.

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