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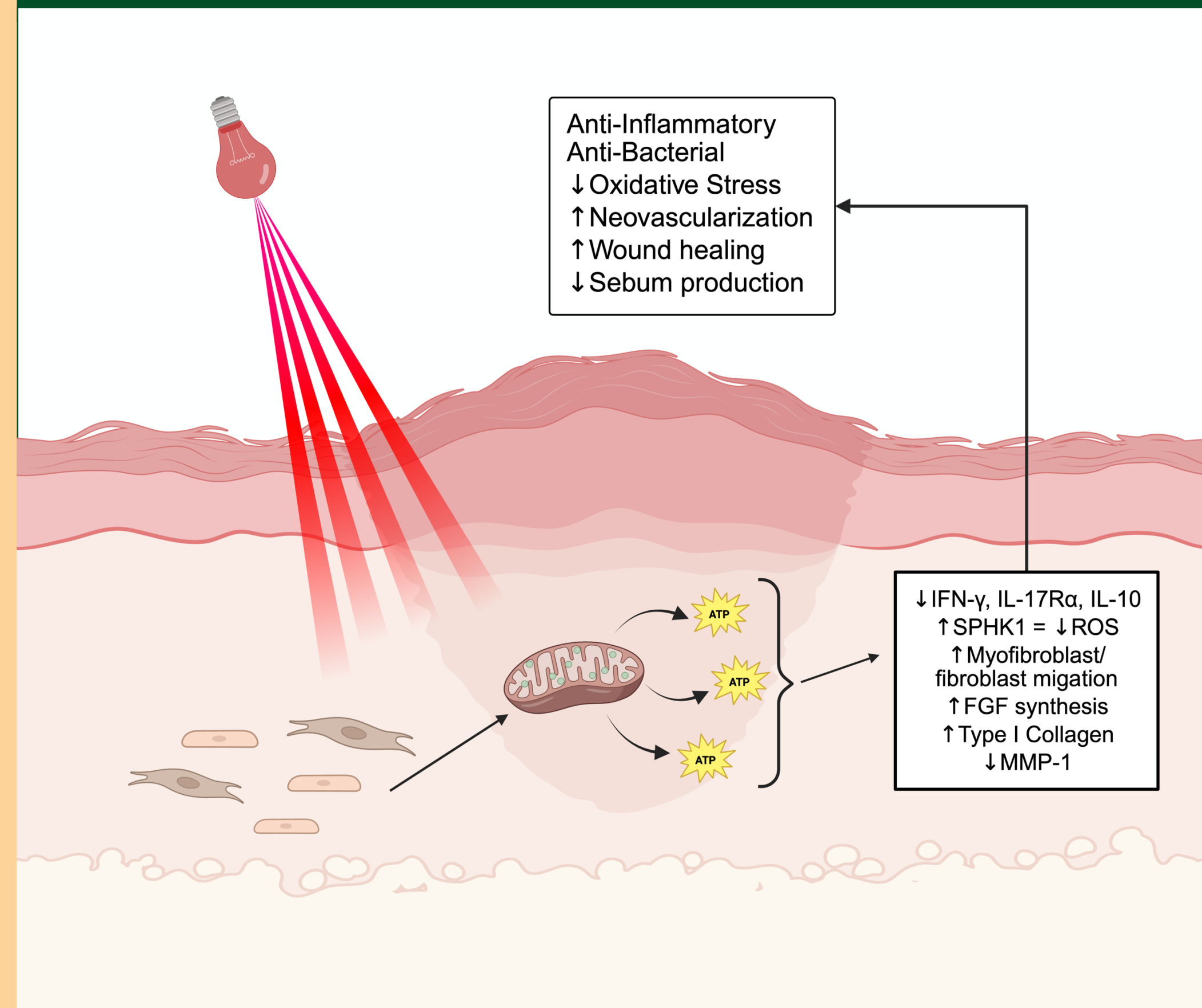
## Introduction

Burn and post-operative scars may result in functional impairment, pain, pruritus, and psychosocial distress. Photobiomodulation using red and near-infrared light-emitting diode (LED) therapy has been shown to stimulate mitochondrial chromophore activation and downstream pathways affecting inflammation, angiogenesis, and collagen remodeling. Despite growing interest, clinical use remains variable due to inconsistent dosing parameters and limited evidence-based practice guidelines. The aim of this study is to evaluate human clinical evidence on LED photobiomodulation for burn and post-surgical scars to assess efficacy, safety, and consistency of treatment outcomes.

## Objective

To evaluate the efficacy and safety of red and near-infrared LED photobiomodulation for scar treatment.

## Mechanism of Action



## Methodology

A systematic review of PubMed, Embase, and Scopus through October 2025 identified randomized or prospective clinical trials evaluating red (633-670nm) or near-infrared (830nm) LED monotherapy for human burn or surgical scars. Inclusion required at least one validated scar outcome or patient-reported measures. Seven studies met inclusion criteria, encompassing 297 patients.

### Red LED Efficacy

Scar Type	Study	Fluence / Session	Number of Sessions	Cumulative Dose	Outcomes	Adverse Events
Burn Scars	<i>Alsharnoubi et al.</i>	16 J/cm <sup>2</sup>	24	384 J/cm <sup>2</sup>	↓ VSS score in treated vs. control (p = 0.003); ↓ pigmentation (p = 0.002), ↓ scar height (p = 0.003)	None
	<i>Gaida et al.</i>	4 J/cm <sup>2</sup>	16	64 J/cm <sup>2</sup>	↓ VSS from 7.10 to 1.42 (LED) vs. 5.86 to 5.40 (placebo)	None
Surgical Scars	<i>Kurtti et al.</i>	20 J/cm <sup>2</sup> (low), 36 J/cm <sup>2</sup> (moderate), 53 J/cm <sup>2</sup> (high)	9	180 J/cm <sup>2</sup> (low), 320 J/cm <sup>2</sup> (moderate), 480 J/cm <sup>2</sup> (high)	At 6 months: moderate fluence ↓ induration by 77.8% vs. 50% (control); low fluence ↓ by 62.6% vs. 40% (control); no group-wise significance	Localized bulla formation (6.7%), localized facial swelling (3.3%), erythema (100%), and warmth (100%)

### Near-Infrared LED Efficacy

Scar Type	Study	Fluence / Session	Number of Sessions	Cumulative Dose	Outcomes	Adverse Events
Hypertrophic Scars	<i>Freitas et al.</i>	4 J/cm <sup>2</sup>	15	60 J/cm <sup>2</sup>	↓ Scar color (p = 0.004), ↑ elasticity (p = 0.016); scar length ↓ 22.2%, width ↓ 44%	None
Surgical Scars	<i>Carvalho et al.</i>	13 J/cm <sup>2</sup>	4	52 J/cm <sup>2</sup>	↓ VSS (2.14 vs. 4.85; p = 0.0002), ↓ scar thickness (0.11 cm vs. 0.19 cm), ↑ malleability (0.14 vs. 1.07; both p < 0.05)	None
	<i>Kim et al.</i>	4.5 J/cm <sup>2</sup>	28	126 J/cm <sup>2</sup>	↑ satisfaction (p = 0.008), ↑ GAS (p = 0.002), ↓ pain (p = 0.004), ↓ VSS (p = 0.004)	None
	<i>Ye &amp; Xiang</i>	60 J/cm <sup>2</sup>	4	240 J/cm <sup>2</sup>	↑ wound healing (96.6% vs 86.8%, p < 0.05), ↓ swelling, pain, anxiety (p < 0.05)	None

## Results

Across pediatric burn scars, red LED (633nm) significantly improved Vancouver Scar Scale (VSS) scores (p = 0.003), pigmentation (p=0.002), and scar height (p=0.003) over 12 weeks. In adults with burn scars, red LED (670nm) reduced VSS scores from 7.10 to 1.42 compared with a smaller change from 5.86 to 5.40 in controls, and reduced pain and pruritus by more than 60%. In surgical scars, dose-dependent improvement was observed. In facelift patients treated with red LED (633nm), induration decreased by 77.8% compared with 50% in control, and observer-rated POSAS scores improved by 57.9%. In a randomized trial following inguinal hernia repair, 830nm LED significantly improved VSS scores (2.14 vs 4.85, p=0.0002), scar thickness, and malleability. In patients undergoing thyroidectomy treated with 830nm LED, VSS scores improved significantly (p=0.004) along with higher patient satisfaction (p=0.008). Across most studies, LED was well tolerated, with transient warmth or erythema as the most common event and no serious complications reported.

## Discussion

Red and near-infrared LED photobiomodulation demonstrates notable improvement in scar thickness, texture, vascularity, and symptom burden in burn and postoperative settings with an excellent safety profile. These findings support LED as a practical, non-invasive adjunct early in scar maturation and potentially during routine postoperative care. As interest grows, standardized treatment parameters and comparative clinical trials are needed to define optimal dosing, establish treatment guidelines, and clarify how LED therapy should integrate with established interventions such as silicone therapy, corticosteroids, and laser-based resurfacing.