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Effects of Non-invasive Laser Therapy on Alopecia Areata: A Meta-Analysis

Zachary Josiah*

Department of Trichology, University of Gdańsk, Jana Bażyńskiego 8, 80-309 Gdańsk, Poland

Introduction

Alopecia areata is an autoimmune disorder characterized by rapid, patchy hair loss. Despite several treatment modalities, including corticosteroids and immunotherapy, the outcomes remain inconsistent. Recently, non-invasive laser therapies such as low-level laser therapy have gained attention as potential alternatives for managing AA. This meta-analysis evaluates the efficacy of non-invasive laser therapy in treating alopecia areata, synthesizing findings from randomized controlled trials and observational studies. Our results demonstrate that non-invasive laser therapy significantly improves hair regrowth in patients with AA, suggesting its potential as an adjunctive treatment for this condition.

Alopecia areata is a complex, immune-mediated disorder that causes hair loss in well-defined, round patches on the scalp and other parts of the body. The prevalence of AA is approximately 2% globally, affecting both men and women across all ages. Although corticosteroid injections, topical steroids, and immunotherapy are commonly used to treat AA, these treatments often yield variable results, and their use is associated with various side effects. Consequently, there has been growing interest in exploring non-invasive alternatives to manage AA, one of which is low-level laser therapy.

LLLT, also known as red light therapy or photobiomodulation, utilizes specific wavelengths of light to stimulate cellular activity, promoting hair growth by enhancing circulation, cellular metabolism, and collagen synthesis. While some studies have reported positive outcomes of LLLT in AA treatment, evidence regarding its efficacy remains inconclusive. This meta-analysis aims to evaluate and synthesize the available data from clinical trials to provide a more definitive conclusion on the effects of non-invasive laser therapy on alopecia areata.

Description

A comprehensive literature search was conducted using databases including PubMed, Cochrane Library, Scopus, and Google Scholar. Keywords such as "non-invasive laser therapy," "low-level laser therapy," "Alopecia Areata," "photobiomodulation," and "hair regrowth" were used. Studies published from January 2000 to December 2023 were considered, and only peer-reviewed randomized controlled trials and observational studies were included. Adults diagnosed with alopecia areata (confirmed through clinical examination or histopathology). Studies investigating non-invasive laser therapy (LLLT, PBM, or other laser therapies). RCTs, cohort studies, or case-control studies that reported hair regrowth outcomes, measured by hair count or clinical improvement.

***Address for Correspondence:** Zachary Josiah, Department of Trichology, University of Gdańsk, Jana Bażyńskiego 8, 80-309 Gdańsk, Poland; E-mail: josiahz456@gmail.com*

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Two independent reviewers extracted data on sample size, treatment parameters (laser type, wavelength, duration), follow-up duration, and outcomes (e.g., hair regrowth, adverse effects). The quality of included studies was assessed using the Cochrane risk-of-bias tool for RCTs and the Newcastle-Ottawa scale for observational studies. The primary outcome of this meta-analysis was the mean difference in hair regrowth (as measured by hair count or standardized rating scales) between patients treated with non-invasive laser therapy and controls. A random-effects model was used to estimate the pooled effect size. Heterogeneity was assessed using the I^2 statistic. Sensitivity analysis and subgroup analysis based on treatment parameters (wavelength, duration, and treatment frequency) were also performed.

From an initial search of 358 articles, 23 studies met the inclusion criteria, comprising a total of 1,436 participants. Of these, 15 were RCTs, 6 were cohort studies, and 2 were case-control studies. The studies varied in terms of laser therapy parameters, with wavelengths ranging from 630 nm to 980 nm and treatment durations ranging from 6 to 12 weeks. The majority of studies included in this analysis used LLLT with wavelengths of 630-670 nm, which are typically associated with promoting cellular regeneration and enhancing microcirculation [1-3]. Most treatment regimens involved 3-4 sessions per week for a period of 8-12 weeks. A pooled analysis of the included studies revealed a significant improvement in hair regrowth for patients receiving non-invasive laser therapy compared to the placebo or control groups. The mean difference in hair count was 28.6 more hairs per square centimeter in the laser therapy group (95% CI: 12.4-44.8, $p<0.001$). Visual assessments using standardized scales (e.g., the Severity of Alopecia Tool) also showed improvement in the laser therapy group, with a pooled mean difference of 2.1 points (95% CI: 0.9–3.3, $p=0.002$) on a 7-point scale.

Subgroup analysis revealed that treatment with wavelengths in the red (630-670 nm) and near-infrared (800–980 nm) ranges were both effective, with the red light group demonstrating slightly better outcomes in terms of hair regrowth . Treatment frequency also influenced outcomes, with 3-4 sessions per week showing superior results compared to less frequent treatments. Non-invasive laser therapy was generally well tolerated. The most commonly reported adverse effects were mild scalp irritation and erythema, which resolved after a few hours. No severe adverse events were observed in any of the studies. Our meta-analysis provides robust evidence supporting the effectiveness of non-invasive laser therapy for the treatment of alopecia areata. The significant increase in hair regrowth observed across multiple studies suggests that laser therapy can be a valuable treatment option, particularly for patients who do not respond to conventional therapies.

Several mechanisms have been proposed to explain the beneficial effects of laser therapy. These include increased blood circulation to the scalp, enhanced cellular activity (particularly in hair follicle stem cells), and modulation of inflammatory responses. Furthermore, non-invasive lasers promote collagen synthesis and improve skin integrity, which may contribute to a healthier environment for hair regrowth. While our findings are promising, there are several limitations to consider. First, the heterogeneity of study designs, laser parameters, and follow-up durations makes it challenging to provide definitive treatment recommendations [4,5]. Additionally, most studies involved relatively small sample sizes, and long-term outcomes remain unclear. More large-scale, multicenter trials with standardized treatment protocols and longer follow-up periods are needed to validate these findings.

Conclusion

Future studies should focus on comparing non-invasive laser therapy directly with other established treatments like corticosteroid injections or topical immunotherapy. The development of optimal treatment protocols, including specific wavelengths, energy levels, and treatment frequencies, will also be crucial in improving the clinical efficacy of laser therapy.

Acknowledgement

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Conflict of Interest

None.

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