Low-Level Light Therapy for the Treatment of Alopecia

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BACKGROUND

Alopecia encompasses a group of conditions that can significantly impact quality of life. While pharmaceutical therapies remain the cornerstone of treatment, laser and light-based therapies, especially low-level light therapy (LLLT), offer promising non-invasive alternatives. LLLT uses specific wavelengths of light to stimulate hair follicle repair, prolong the hair growth phase, and promote regrowth. Recent advancements in at-home devices and dual-wavelength LED systems have expanded access to these therapies. This review explores the role of LLLT in treating alopecias, evaluating its mechanisms, efficacy, and clinical applications.

METHODS

A PubMed search using terms related to alopecia and laser/light therapy was conducted. Results were limited to English-only articles from 2020-2025, excluding duplicates. Additional articles were identified through citation tracking. Studies not focused on light-based therapies were excluded.

RESULTS & DISCUSSION

Androgenetic alopecia (AGA) pathophysiology centers around the androgen dihydrotestosterone (DHT), a potent metabolite of testosterone. LLLT has emerged as a promising treatment modality for AGA. In-office and at-home devices typically use red (wavelengths between 620-680nm), which penetrate the scalp and stimulate follicular cells. The proposed mechanisms include increased ATP production in mitochondria, upregulation of anti-apoptotic proteins, improved microcirculation, and modulation of inflammatory mediators in the hair follicle environment. A dual wavelength LED LLLT device (Revian System, Revian Inc.) has been shown to decrease DHT production via stimulated nitric oxide production within cells specific to hair growth. Results from a prospective, multiple studies demonstrated strong compliance and significantly increased hair count , indicating both ease of use and efficacy. Moreover, combining LLLT with established treatments such as minoxidil or finasteride has been shown to potentially enhance clinical outcomes compared to monotherapy. In a randomized control trial by

RESULTS & DISCUSSION (CONT.)

Lanzafame, *et. al.*, participants using both LLLT and 5% topical minoxidil demonstrated significantly greater increases in hair density than those using either therapy alone, suggesting a synergistic effect. Similarly, a study by Munck, *et. al.* found that combining finasteride with LLLT led to improved hair growth parameters, including hair count and patient satisfaction, when compared to finasteride alone. LLLT is generally well-tolerated with minimal reported side effects, the most common being transient, self-resolving scalp pruritus.

Telogen effluvium (TE) is a non-scarring, diffuse alopecia that results from a disruption of the hair cycle, specifically a premature shift of hair follicles from the anagen (growth) phase to telogen (resting) phase. LLLT enhances mitochondrial activity, increases ATP production, and prolongs the anagen phase, directly addressing the underlying cause of TE. In a study by Amer, *et. al.*, seven women with clinically diagnosed TE were treated with a LLLT device twice weekly for 16 weeks. While the improvement in total hair count was not statistically significant (mean increase of 8.7%; p-value = .143), patients reported subjective benefits in hair shedding and density. Notably, 71.4% of patients reportedly improved hair density, and 57.1% experienced less hair fall, with no serious adverse effects. Similarly, Sorbellini, *et. al.* reported that LED-based LLLT may support recovery in stress-induced and reactive TE by enhancing vascular and metabolic support to follicles. The therapy was proposed as a useful non-invasive adjunct, particularly for chronic or relapsing TE, although more robust studies are needed to confirm long-term outcomes.

Alopecia areata (AA) is an autoimmune disorder characterized by non-scarring, patchy hair loss, most commonly affecting the scalp, although any hair-bearing area can be involved. LLLT has been proposed to modulate immune responses in AA through anti-inflammatory and immunoregulatory mechanisms. While evidence remains limited, case series and pilot studies suggest that LLLT can promote hair regrowth by reducing perifollicular inflammation and enhancing microcirculation. Patients with AA were able to see significant increases in both hair assessment scales and in manual hair counting after twice weekly LLLT treatments for two months. This is partly attributed to the ability of LLLT to activate cytochrome C in mitochondria, increasing electron transport and therefore ATP. This reverts hair follicles out of the dormant, telogen phase and into the growth, anagen phase. Additional proposed mechanisms include additional, unrecognized pathways involved in the pathogenesis of AA including those on the subcellular and molecular level that LLLT are able to reduce or reverse completely.

Frontal fibrosing alopecia (FFA) is a primary lymphocytic cicatricial alopecia and a clinical variant of lichen planopilaris. Traditional treatments for FFA have included topical and intralesional corticosteroids, calcineurin inhibitors, hydroxychloroquine, 5aR inhibitors, and systemic immunosuppressants such as mycophenolate mofetil and methotrexate. However, recent interest has emerged in LLLT as a potential adjunctive option due to its ability to stimulate follicular stem cell activity, enhance mitochondrial function, and exert

RESULTS & DISCUSSION (CONT.)

anti-inflammatory effects, which may benefit early-stage FFA where active inflammation precedes irreversible fibrosis.

Central centrifugal cicatricial alopecia (CCCA) is the most common form of scarring alopecia in women of African descent and is characterized by progressive hair loss that typically begins at the crown and spreads centrifugally.While the use of light-based therapy in CCCA is not well established, emerging interest in LLLT has prompted clinical exploration. Specifically, promising results from a dual wavelength LED device has opened a new avenue in the treatment for CCCA.

Traction alopecia (TA) is a form of hair loss caused by prolonged tension on the hair shafts due to certain hairstyles and grooming practices. There is limited but emerging evidence that LLLT may play a supportive role in the management of early-stage TA. LLLT's mechanism of action (see prior sections) could be beneficial if active follicles remain.

Secondary scarring alopecia arises from external insults or systemic diseases that destroy the hair follicle and replace it with fibrotic tissue. Though not widely studied in secondary scarring alopecias, LLLT has shown early promise. A case report described significant clinical improvement in a patient with recalcitrant DLE treated with LLLT, noting reduced erythema and scaling, improved skin texture, and partial hair regrowth.

Low-level light therapy (LLLT) is a safe, non-invasive option that has demonstrated strong efficacy in androgenetic alopecia and growing promise in other alopecias. Evidence suggests it may enhance hair density, reduce inflammation, and improve outcomes when used alone or in combination with established treatments. While data in conditions such as telogen effluvium, alopecia areata, and cicatricial alopecias remain limited, early results are encouraging. LLLT therefore represents a valuable adjunct in the evolving management of hair loss disorders.

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