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Examining the Safety and Efficacy of Low-Level Laser Therapy for Male and Female Pattern Hair Loss: A Review of the Literature

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Low-level laser therapy · Androgenetic alopecia · Female pattern hair loss · Alopecia

Abstract
Purpose: Pattern hair loss is the most common type of alopecia. Standard of care involves long-term use of topical medications with limited effectiveness. Low-level laser therapy (LLLT) has become a popular alternative treatment. Here, we examine published clinical trials to establish whether the breadth of evidence supports LLLT for pattern hair loss. ***Methods:*** A literature search was conducted within the PubMed, Embase, Scopus, and Cochrane Trials databases to identify original articles evaluating hair regrowth following LLLT. Articles were selected based on use of 600–1,100 nm wavelengths, treatment time ≥16 weeks, and objective evaluation for hair regrowth. ***Results:*** Ten randomized controlled trials were included, of which 8 compared LLLT to sham device and 1 to no treatment. The study populations varied, with 3 studies evaluating only women. All sham-device controlled studies demonstrated statistically significant increase in hair diameter or density ($p < 0.01$) following LLLT. ***Discussion:*** Based on our review of the literature, LLLT appears to be effective for treating pattern hair loss in both men and women. These laser devices have good safety profiles, with only minor adverse effects reported. However, physicians should be cautious when drawing conclusions as some studies included have a relationship with industry.

Introduction

Pattern hair loss, also known as androgenetic alopecia (AGA), or male pattern hair loss (MPHL) in males and female pattern hair loss (FPHL) in females, is the most common type of alopecia [1]. Prevalence increases with age, and a study found that 57% of women and 73.5% of men over the age of 80 suffered from pattern hair loss [2]. Because hair is an important aspect of human appearance, which is commonly used for identification and is one factor of physical appeal, hair loss can lead to diminished quality of life and flawed social worth [3]. Individuals suffering from hair loss find the experience stressful and report negative body image, low self-esteem, and loss

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Table 1. Jadad criterion scoring

	Criteria (yes: 1, no: 0)					
	was there randomization mentioned?	was double blinding mentioned?	was the method of randomization described?	was the method of double blinding mentioned?	were subjects who withdrew or dropped out described?	total study score
Leavitt et al. [18]	1	1	0	0	1	3
Kim et al. [19]	1	1	0	0	1	3
Jimenez et al. [17]	1	1	1	1	1	5
Lanzafame et al. [20]	1	1	0	1	1	4
Lanzafame et al. [21]	1	1	0	1	1	4
Friedman and Schnoor [22]	1	1	0	1	1	4
Barikbin et al. [23]	1	0	0	0	0	1
Mai-Yi Fan et al. [24]	1	1	0	1	1	4
Esmat et al. [25]	1	0	1	0	0	3
Suchonwanit et al. [26]	1	1	1	1	1	5

of self-confidence [4, 5]. This tends to be magnified in women, who were shown to find hair loss more distressing than men and do not adapt as well as men [4, 6, 7].

MPHL, also known as AGA, is characterized by a progressive decline in hair fiber production by scalp hair follicles and their subsequent miniaturization. MPHL/AGA is due to a combination of genetic predisposition and the effect of androgens. Although testosterone is necessary for the development of male balding, its more potent metabolite, dihydrotestosterone, is responsible for influencing follicular regression [8]. While the role of androgens in MPHL is well illustrated, its role in FPHL has been questioned [9].

Established medical management for pattern hair loss to date consists of 5α-reductase inhibitors (finasteride and dutasteride) and topical minoxidil, which require frequent and indefinite use and have limited effectiveness [10]. Minoxidil acts as a potassium channel opener on the smooth muscles of the peripheral arteries. It is postulated that this potassium channel activity is required for progression to the G1 stage of the cell cycle, cellular proliferation, and ultimately in this case hair growth [11, 12]. Surgical options are restricted to patients due to high cost and supply of donor hair follicles [10, 13].

Due to the need for more successful therapies, low-level laser therapy (LLLT) has emerged as a novel therapy to treat pattern hair loss. LLLT has become widely popular due to commercially available devices that can be used at home, are of low cost, are easy to navigate, and have a great safety profile. To date, there are 29 FDA cleared devices for the treatment of pattern hair loss in males, females, or both [14]. LLLT has biostimulatory effects on tissues and is presumed to prolong anagen (growth phase), stimulate anagen reentry from telogen (resting phase), and inhibit early transition to catagen (regression phase) [9, 15, 16]. Additionally, they stimulate the production of terminal hair from follicles that have been producing pseudo-vellus hair [17]. However, there is still considerable skepticism from the dermatology community about its use to promote hair growth due to lack of literature reviews looking at overall benefits of LLLTs compared to other modalities, limited understanding of mechanisms, and inadequately defined treatment parameters. For this reason, the purpose of this review is to examine published controlled clinical trials, which include comparison of LLLT devices to sham device or no treatment for their safety and effectiveness for the treatment of pattern hair loss in both males and females.

Methods and Materials

Literature Search

A broad literature search was conducted through PubMed, Embase, Scopus, and Cochrane Trials up to January 2020 to identify original articles that evaluate hair regrowth upon LLLT. The databases were searched using different combinations of the following keywords: alopecia, pattern hair loss, androgenetic alopecia, hair loss, hair regrowth, low level laser therapy, low level light therapy, photobiomodulation, or low energy laser irradiation.

Inclusion and Exclusion Criteria

All search hits from all 4 databases were screened and examined for relevant abstracts and titles. Full text of relevant studies was reviewed to determine appropriateness according to established inclusion criteria. Case reports and case series were excluded. Articles were recognized as appropriate when they (a) included hu-

Table 2. Summary of clinical trials

Author	Laser type	Total patients	Alopecia type	Age, years	Treatment regimen	Assessed parameters	Effectiveness
Leavitt et al. [18]	HairMax Laser Comb	110 males	MPHL	30–60	655 nm, 15 min, 3×/week for 26 weeks	Computer aided hair count, subject assessment	Increase in terminal hair density ($p < 0.0001$) Hair regrowth ($p = 0.01$)
Kim et al. [19]	Oaze helmet-type 3R LLLT device	40 total (26 males and 14 females)	MPHL and FPHL	Treated: 43.9±12.2 Sham: 44.5±11.4	18 min, 1×/day for 24 weeks	Change in hair density Change in hair shaft diameter	Terminal hair density ($p < 0.003$) Hair thickness ($p < 0.01$)
Jimenez et al. [17]	HairMax Laser Comb	128 males and 141 females	MPHL and FPHL	25–60	Three groups: 15 min with 655 nm 11 min with 655 nm 8 min with 635 nm All groups: whole scalp treated 3×/day for 26 weeks	Change in terminal hair density from baseline	Hair density 9- and 12-beam laser groups in women ($p < 0.0001$) 7-, 9-, and 12-beam in men ($p = 0.0017$, $p = 0.0249$, $p = 0.0028$)
Lanzafame et al. [20]	iGrow (TOPHAT655 unit)	44 males	Hamilton Norwood IIa–V MPHL	18–48	25 min, every other day for 16 weeks	Percent increase in hair counts from baseline	Hair count ($p < 0.0001$) Hair growth ($p < 0.001$)
Lanzafame et al. [21]	iGrow (TOPHAT655 unit)	42 females	Ludwig scale I–II FPHL	18–60	25 min every other day for 16 weeks	Percent increase in hair counts from baseline	Hair count ($p < 0.0001$) Hair growth ($p < 0.001$)
Friedman and Schnoor [22]	Capillus	44 females	Ludwig scale I–II FPHL	18–60	650 nm, 30 min every other day for 17 weeks	Percent increase in hair count from baseline	Hair count ($p < 0.001$)
Barikbin et al. [23]	Laser hat versus laser scanner	90 patients	MPHL and FPHL	18–70	Three groups 655 nm red light via laser hat 655 nm red laser + 808 nm infrared laser using a laser scanner No treatment Groups 1 and 2: treated 3×/week for 4 months	Change of terminal hair density from baseline	Terminal hair density ($p < 0.0001$) Laser scanner group had slightly better results than laser hat
Mai-Yi Fan et al. [24]	IRestore	100 patients	MPHL and FPHL	25–60	30 min, 3×/week for 24 weeks; LLLT on one side of head and sham device other side	Change in hair count, thickness, and density	Hair coverage ($p < 0.001$) Hair thickness ($p < 0.001$)

Table 2 (continued)

Author	Laser type	Total patients	Alopecia type	Age, years	Treatment regimen	Assessed parameters	Effectiveness
Esmat et al. [25]	Topical minoxidil and/or iGrow LLLT device	45 females	FPHL	25–49	Three groups: Topical minoxidil 5% 2×/day for 4 months 655 nm, 25 min, every other day for 4 months Groups 1 and 2 received treatment for 4 months	Analyzed follicle diameter, number of follicles, and hair density	Hair follicle count – groups 2 and 3 (p value not recorded)
Suchonwanit et al. [26]	RAMACAP LLLT device	40 subjects (20 females and 20 males)	MPHL and FPHL	18 or older	660±10 nm, 20 min, 3×/week for 24 weeks	Analyzed hair density and hair diameter	Hair density ($p = 0.002$) Hair diameter ($p = 0.009$)

MPHL, male pattern hair loss; LLLT, low-level laser therapy; FPHL, female pattern hair loss.

man subjects, (b) used a wavelength between 600 and 1,100 nm, (c) had a control group, (d) used an objective measure for hair regrowth, and (e) involved a 16-week or greater clinical trial.

Quality of Evidence

The quality of each of the papers was assessed using the Jadad scoring (also called the Oxford quality scoring) system (Table 1).

Results

A total of 10 randomized controlled trials (RCTs) met our inclusion and exclusion criteria. Three studies included only female subjects, 2 studies included only male subjects, and 5 included both. Five different laser devices were used. Jadad scores (Table 1) ranged from 1 to 5, with a mean of 4. Each study is described below and summarized in Table 2.

Leavitt et al. [18] described the use of the HairMax Laser Comb device for treating AGA. The 110 patients were all males and were classified with Norwood-Hamilton MPHL scores (IIa–V). In this randomized, double-blinded, sham device-controlled, multicenter trial, the subjects were treated with either the HairMax Laser Comb or a sham device (2:1 ratio). The patients were asked to use the device 3 times a week for 15 min on non-concurrent days for the duration of 26 weeks/6 months. Although investigators' assessment of overall hair growth showed no significant difference between the groups, treatment with the HairMax Laser Comb had a mean increase in terminal hair density of +19.8 hairs/cm^2 compared to the sham device that had a mean decrease of −7.6 hairs/cm^2 at 26 weeks. These results were statistically significant ($p < 0.0001$). Further, the HairMax Laser Comb group perceived a greater improvement in hair regrowth at 26 weeks ($p = 0.01$) and had a more favorable overall assessment according to the subjects' study questionnaire. Other than 4 cases of mild paresthesia and 4 cases of mild urticaria, the treatment with the HairMax Laser Comb was well tolerated with no severe complications reported. This study suggests that the HairMax Laser Comb device was not only perceived to have a greater improvement in hair regrowth but was also effective in increasing terminal hair density in males.

Kim et al. [19] described the use of the Oaze helmet-type 3R LLLT device for treating AGA and FPHL. In this randomized, double-blinded, sham device-controlled, multicenter trial, 40 subjects including both female and male patients were initially enrolled and treated with either the Oaze helmet-type 3R LLLT device or a sham device (1:1 ratio) for a duration of 18 min, once a day for 24

weeks. Male patients were classified with Norwood-Hamilton MPHL scores (III–IV), and female patients were classified with Ludwig scores (I–III). Primary and secondary endpoints were assessed for a total of 29 patients (LLLT, $n = 15$; sham device, $n = 14$). Treatment with the Oaze helmet-type 3R LLLT device had a statistically significant mean increase in terminal hair density of $+17.2 \pm 12.1$ hairs/cm^2 compared to the treatment with the sham device that had a mean decrease of -2.1 ± 18.3 hairs/cm^2 at 24 weeks ($p < 0.003$). Furthermore, treatment with the Oaze helmet-type 3R LLLT device had a statistically significant mean increase in hair thickness of $+12.6 \pm 9.4$ μm compared to the treatment with the sham device that had a mean increase of $+3.9 \pm 7.3$ μm at 24 weeks ($p < 0.01$). Investigators perceived a significantly greater improvement of hair regrowth in the treatment group versus the control group ($p < 0.05$). Subjects' global assessment of hair growth and subjects' satisfaction were not statically significant. The treatment with the Oaze helmet-type 3R LLLT device resulted in no severe complications. Reported adverse effects in both the treatment and control groups included headache, skin pain, pruritis, erythema, and acne; however, there was no significant difference in incidence of adverse events between the 2 groups. The study was a sham device-controlled trial, suggesting that Oaze helmet-type 3R LLLT device was very effective in increasing terminal hair density and hair thickness in both females and males.

Jimenez et al. [17] described the use of HairMax Laser Comb device for treating AGA and FPHL. A total of 128 males with Norwood-Hamilton Baldness scores IIa–V and 141 female patients with Ludwig-Savin Baldness score I-4, II-1, II-2, or frontal were included in this large randomized, double-blinded, multicenter, sham device-controlled study. The subjects were randomly treated with either the HairMax Laser Comb device with 7, 9, or 12 laser beams or a sham device 3 times a week for 26 weeks. The treatment with the HairMax Laser Comb device showed a statistically significant increase in terminal hair density from baseline in all treatment groups compared to the treatment with the sham device at 26 weeks. Further, a higher percentage of subjects in the treatment group perceived overall improvement of hair loss condition, thickness, and fullness of hair elicited via self-assessment compared to the control group. Side effects reported included dry skin (5.1%), pruritis (2.5%), scalp tenderness (1.3%), irritation (1.3%), and a warm sensation at the site (1.3%). There were no side effects that lead to discontinuation or interruption of the study. This study is the largest published randomized, double-blinded, sham device-controlled study to date and suggests evidence for the efficacy and safety of the HairMax Laser Comb device in treating AGA and FPHL, increasing terminal hair density in both male and female patients.

Lanzafame et al. [20] described the use of the iGrow (TOPHAT655 unit) helmet-type device for treating AGA. In this randomized, double-blinded, sham device-controlled trial, 41 men with Norwood-Hamilton Baldness scores IIa–V were treated with either the iGrow (TOPHAT655 unit) device or a sham device (1:1 ratio). The patients were asked to use the device for 25 min every other day for 16 weeks. Treatment with the iGrow (TOPHAT655 unit) LLLT device had a statistically significant mean percent hair count increase of +39% compared to the treatment with the sham device at 16 weeks (67.2 ± 33.4, LLLT, $n = 22$; 28.4 ± 46.2, sham, $n = 19$; $p = 0.001$). No severe complications, adverse events, or side effects were reported. Lanzafame et al. [20] suggested iGrow (TOPHAT655 unit) helmet-type device to be a very efficacious and safe tool that increases hair counts form baseline and improves AGA in male patients.

Lanzafame et al. [21] described the use of the iGrow (TOPHAT655 unit) helmet-type device for treating FPHL. In this randomized, double-blinded, sham device-controlled trial, 42 female patients with Ludwig-Savin Baldness scores (I-2–II-2) were treated with either the iGrow (TOPHAT655 unit) device or a sham device (1:1 ratio). The patients were asked to use the device for 25 min every other day for 16 weeks. Treatment with the iGrow (TOPHAT655 unit) LLLT device resulted in a statistically significant mean percent hair growth increase of $+48.07 \pm 17.61$ compared to the treatment with the sham device with a mean percent hair growth increase of $+11.05 \pm 48.30$ at 16 weeks ($p < 0.001$). This correlates to a 37% increase in hair growth in the treatment versus the control group. No severe complications, adverse events, or side effects were associated with the iGrow (TOPHAT655 unit) LLLT device. Similar to their previous study conducted in male patients only, Lanzafame et al. [21] advocated for safety and efficacy of the iGrow (TOPHAT655 unit) helmet-type device to improve hair growth in female patients.

Friedman and Schnoor [22] described the use of the Capillus Handi-Dome Laser device for treating FPHL. In this randomized, double-blinded, sham device-controlled trial, 44 female patients with Ludwig-Savin Baldness scores (I-2–II-2) were treated with either the Capillus Handi-Dome Laser device or a sham device (1:1 ratio). The patients were asked to use the device for 30 min every other day for 17 weeks. Treatment with the Capillus Han-

di-Dome Laser device resulted in a statistically significant increase in terminal hair counts of 51% compared to the treatment with the sham device at 17 weeks ($p < 0.001$). The treatment with the Capillus Handi-Dome Laser device resulted in no severe complications and no adverse events or side effects were reported at any time during the study. This study indicated that Capillus Handi-Dome Laser device successfully increased terminal hair counts and improved FPHL in female patients.

Barikbin et al. [23] described the use of the red light laser hat and the red light laser scanner for treating AGA and FPHL. In this randomized, double-blinded, controlled study, a total of 90 female and male patients were divided into 3 equal groups – Group 1: patients received 655 nm red light via laser hat ($n = 30$); Group 2: patients received 655 nm red laser plus 808 nm infrared laser using a laser scanner of hair growth device ($n = 30$); and Group 3: patients received no laser as the control group ($n = 30$). Patients were treated 3 times a week for up to 4 months. A statistically significant increase in the number of terminal hairs was observed in both treatment groups ($p < 0.0001$). The treatment with a laser scanner resulted in higher increase in terminal hair density compared to the treatment with the laser hat (mean increase in terminal hair density 9.61 vs. 9.16/cm^2). These results were statically significant ($p < 0.0001$). No adverse effects were observed in this study. This study results showed that both red light laser hat and red light laser scanner successfully increased terminal hair density and improved AGA without any significant adverse effects.

Mai-Yi Fan et al. [24] described the use of the iRestore ID-520 helmet-type LLLT device for treating AGA and FPHL. In this randomized, double-blinded, self-comparison, sham device-controlled study, 100 subjects including male patients with Norwood-Hamilton male pattern hair loss scores IIa–V and female patients with Ludwig-Savin classification scores I4–II-2 were treated with the iRestore ID-520 helmet-type LLLT device on one side of the head, and a sham device on the contralateral side. Half of the subjects were treated with the iRestore ID-520 helmet-type LLLT device on the right side and the sham device on the left side, and the other half of the subjects with the opposite light sources on their respective sides. The patients were asked to use the device for 30 min 3 times a week for 24 weeks. The side treated with the iRestore ID-520 helmet-type LLLT device resulted in a significantly greater hair coverage compared to the side treated with the sham device (14.2 vs. 11.8%) at 24 weeks ($p < 0.001$). Furthermore, the side treated with the iRestore ID-520 helmet-type LLLT device resulted in greater improvement in hair thickness, hair count, hair coverage, and the investigators' global assessment of hair regrowth compared to the side treated with the sham device at 24 weeks. These results were all statistically significant ($p < 0.001$, $p < 0.001$, $p < 0.001$, and $p < 0.001$, respectively). Subjects' global assessment of hair growth and subjects' satisfaction were not statically significant. There were no cases of severe complications, interruption of the study, or discontinued use of the study device. Adverse effects were reported in 29 patients (29.3%) and included eczema (4.0%), pruritis (3.0%), and acne (1.0%). Most of the aforementioned adverse events resolved within 2 weeks. This study suggests that the iRestore ID-520 helmet-type LLLT device successfully increased hair coverage, hair thickness, and hair count and resulted in a better global assessment of hair regrowth by the investigators without causing any serious side effects.

Esmat et al. [25] described the use of the iGrow LLLT helmet device for treating FPHL. In this randomized, double-blinded, controlled study, 45 female patients with a diagnosis FPHL and Ludwig-Savin Baldness scores I–III were divided into 3 equal groups – Group A: patients were asked to apply topical minoxidil 5% twice a day for 4 months; Group B: patients used the iGrow LLLT helmet device for 25 min every other day for 4 months; and Group C: patients received both topical minoxidil 5% twice a day and the iGrow LLLT helmet device for 25 min every other day for 4 months. A statically significant increase in the number of hair follicles at 4 months was observed in both Group B and Group C. There was no significant difference between the diameters of the largest hair follicle in any of the 3 groups. The treatment with the iGrow LLLT helmet device resulted in no severe complications. Side effects reported include self-limiting irritation (27% of patients in Group C vs. 40% of patients in Group A), scalp tenderness (27% of patients in Group B vs. 40% of patients in Group C), warm sensation (20% of patients in group B vs. 27% of patients in group C), and initial increase in hair shedding (80% of patients in group A vs. 60 of patients in group C). These results suggest that the iGrow LLLT helmet device did not increase the diameter of the largest hair follicle but that it effectively increased the number of hair follicles at the end of the treatment period in females suffering from FPHL with a satisfactory side effect profile.

Suchonwanit et al. [26] described the use of the RAMACAP helmet-type LLLT device for treating AGA and FPHL. In this randomized, double-blinded, sham device-controlled study, 36 total subjects including both female patients with Ludwig-Savin Baldness score I–III and male

patients with Norwood-Hamilton Baldness scores III–V were treated with either the RAMACAP helmet-type LLLT device or a sham device (10 men and 10 women in each group). The patients were asked to use the device for 20 min 3 times per week for 24 weeks. Treatment with the RAMACAP helmet-type LLLT device resulted in a statistically significant increase in terminal hair counts of 51% compared to the treatment with the sham device at 17 weeks ($p < 0.001$), as well as a statistically significant increase in hair diameter at 24 weeks ($p = 0.009$). Both investigators and subjects perceived greater improvement in hair regrowth in the treatment group versus the control group, and the results were statistically significant ($p = 0.0002$ and $p = 0.0026$, respectively). The treatment with the RAMACAP helmet-type LLLT device resulted in no adverse events, discontinuation, or interruption of the study. Overall, Suchonwanit et al. [26] proposed that the RAMACAP helmet-type LLLT device demonstrated the ability to safely improve AGA and FPHL by increasing terminal hair counts and hair diameter.

Discussions

The purpose of our systematic review was to evaluate the published controlled clinical trials utilizing LLLT to determine if the data support its use for treatment of pattern hair loss. Overall, the 10 RCTs suggested satisfactory results following laser treatment and most devices had favorable safety profiles. All of the trials found significant increases in terminal hair counts, hair growth, and hair coverage in treatment groups ($p < 0.01$).

All 10 RCTs included in this review had control groups, and the studies were carried out for at least 16 weeks, with the longest treatment period being 26 weeks. Furthermore, all of the studies employed objective measurements of hair loss or regrowth: the Norwood-Hamilton scale for men and the Ludwig-Savin scale for women. Eight out of the 10 studies used sham devices as controls. Of the 2 that did not use sham devices, minoxidil was used for one treatment group [25] and the other, no treatment was given to the control group [23].

The data acquired from each study used different devices, laser parameters, and regimens. Various laser devices were utilized, including the HairMax Laser Comb device, the Oaze helmet-type 3R LLLT device, the iGrow (TOPHAT655 unit) helmet-type device, and several others. Laser wavelengths included 660 ± 10 and 655 nm (Table 2). Though each study developed their treatment standards, one benefit of this review is that laser parameters and regimens were reported by all but one of the RCTs, so comparisons can be made. Four of the RCTs [17, 18, 24, 26] implemented laser treatment 3 times per week for between 15 and 25 min depending on the study. Another 4 studies [20–22, 25] required treatment every other day for 25 or 30 min. One study [19] chose to have participants treated every day. Of note, subjects' assessment of satisfaction was not favorable for this study, perhaps due to daily treatment requirements.

Only one study reviewed [25] and compared commonly prescribed pharmacological treatments for AGA with LLLT. In this case, minoxidil 5% topical solution was used. This study included 3 treatment groups: one in which patients applied minoxidil twice a day for 16 weeks, one in which patients used the iGrow LLLT helmet device every other day, and a third group that used both minoxidil and the laser. This study suggested that both the group that used laser alone and the group that used laser in combination with minoxidil showed significant increases in the number of hair follicles at the end of treatment ($p < 0.05$). Moreover, the results demonstrated that LLLT alone did result in slightly better outcome than minoxidil alone, while combination therapy was found to be superior to either treatments alone, proposing an important role of LLLT in positive outcomes.

In order to objectively measure the efficacy of LLLT, researchers used standardized forms of imaging and counting techniques to assess hair density before and after treatment. In most cases, a location of interest was identified on the scalp and hairs were trimmed in a circular area ranging from approximately 1 to 3 cm^2. A pinpoint tattoo was then placed at the center of the clipped area for use as a guide in order to clip and image the same area at subsequent visits. In 4 of the studies [19, 24–26], a phototrichogram was used for measurement, either a Folliscope® (Lead M, Seoul, South Korea) or an IBS-01 Pro Beauty Scope (Kowa Optics Corp., New Taipei City, Taiwan). Three of the studies [20–22] used a custom-built camera apparatus consisting of a Canon Rebel T3i camera system (Canon, Melville, NY, USA) equipped with a Tamron macro lens (Tamron, Commack, NY, USA). In general, hair counts were performed by a single blinded observer and in most cases, images sent for independent count via a computer-assisted software.

In evaluating LLLT for AGA, we must consider not only the efficacy of laser devices, but the safety of their use as well. Most subjects in the studies reported only mild side effects, commonly including pruritis [17, 19, 24], acne [19, 24], and scalp tenderness [17, 25]. No studies reported any severe adverse events that lead to disruption

or discontinuation of treatment, and most of the aforementioned side effects resolved within 2 weeks. Another important aspect to consider in the use of LLLT is the satisfaction of patients following treatment. Five of the studies included assessment of patient satisfaction with treatment. In most cases, treatment groups were found to have a more favorable overall assessment when compared to control groups. Moreover, LLLT devices appear to be a safe and efficacious form of treatment for AGA. They are of relatively low cost, are easy to use, and are therefore likely to result in high levels of compliance. Although all 10 studies suggest LLLT devices to also be very effective, there are a couple of significant topics we would like to discuss.

First, it is important to note that some of the studies included in this review have a clear relation with an industry; the relationship includes either sponsoring the study or involvement in evaluating the results of the study. It is then possible that such relation can affect the validity of the study designs, results, and/or conclusions. Second, the automated digital imaging analysis or the Trichoscan may be an easy method to evaluate hair growth but has been shown as imperfect and error-prone [27]. That said, although Trichoscan evaluations suggest promising results in terms of the numbers (i.e., increase in hair density and hair thickness), the articles included have shown little clinical improvement overall. Given the increase in terminal hair counts in all studies, perhaps a longer duration of treatment could lead to clinical improvement. That said, although LLLT may be an alternative safe and effective tool for treating pattern hair loss, more studies with additional focus on clinical improvements, comparison of diverse laser settings, and treatment regimens will be vital for dermatologists to develop a more standardized treatment regimen that yields maximum efficacy for patients with pattern hair loss. Furthermore, dermatologists should look out for any potential connections with industries when evaluating the literature and making decisions based on a particular clinical trial when it comes to both efficacy and safety.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Every author listed meets the qualifications for authorship and has had the opportunity to read and comment upon the submitted manuscript.

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