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The effect of 1540-nm fractional erbium-glass laser in the treatment of androgenic alopecia

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Abstract

Background: Androgenic alopecia is common, chronic dermatologic disorder. A variety of lasers and light sources appear to be safe and effective in the treatment of AGA.

Aims: To evaluate the efficacy and safety of 1540-nm fractional erbium glass laser in the treatment of AGA.

Patients/Methods: This was an interventional therapeutic study for the treatment of patients with AGA. The patients received 10 sessions with 1540-nm fractional erbium glass laser at 2-week intervals. The assessment of the response was done before and at the end of follow-up period, both objectively (the change in the density of terminal hair and the diameter of the hair shaft) and subjectively (patient satisfaction). Any adverse effects were documented during the study.

Results: Forty-seven out of 51 patients completed the study. After 5 months of laser treatment, the density of hair and hair thickness was significantly increased in both males and females (*P* value .001).

Conclusion: The 1540-nm fractional erbium-glass laser seems to be an effective and safe option for treatment of patients with AGA. The improvement was accomplished in a short period.

KEYWORDS

1540 nm, androgenic alopecia, erbium-glass, fractional, laser

1 | INTRODUCTION

Androgenic alopecia (AGA) is the androgen-mediated conversion of susceptible terminal hairs into vellus hairs that result in a progressive, patterned hair loss that happens when people with a genetic predisposition are exposed to androgens.[1] AGA was found in men and women of all races and ethnicities. At 40 years of age, 40% of women and nearly 40% of men have visible symptoms of hereditary hair loss, and at 50 years of age, 50% of both sexes show signs of disease.[2]

In men, the expression of AGA is specifically related to the androgen hormone dihydrotestosterone (DHT). The enzyme 5α-reductase, which is of two isoforms type I and type II, converts testosterone to DHT. The genetic lack of type II 5α-reductase prevents male AGA from developing. Dihydrotestosterone is involved in the appearance of miniaturized hair shafts and follicles, and decreased skin and blood levels have been correlated with miniaturization reversal.[3]

In women, similar pathophysiology associated with androgen is suggested. Women who develop balding rapidly after puberty often

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have a positive family history for male and female pattern hair loss. In women was developed patterned alopecia during the perimenopause and menopause; this may be due to genetic predisposition as well as changes in androgen metabolism at the hair follicle level and systemic hormonal changes.[4] For men, the progression of the hair loss occurs in an orderly manner and has been well documented by Hamilton[5] and Norwood[6] grading based upon front-parietal and frontal recession as well as vertex thinning. Women with AGA could be manifested as an episode of increment of hair shedding with a visible reduction in hair volume, increased hair shedding with hair volume loss over the crown, or as diffuse thinning over the crown without a history of hair shedding.[7] The central part widening may follow a pattern of "Christmas tree" and is used to score hair loss.[8] The most common pattern of FPHL, however, is diffuse central thinning of the crown with frontal hairline preservation.[9] Classification of severity of FPHL is carried out via the Sinclair scale[10] or Ludwig scale.[11]

Various types of light sources and laser were used for androgenic alopecia, and some success has been recorded.[12] Low-level laser therapy (LLLT) of 650-900 nm wavelengths at 5 mW was suggested as an effective treatment option for male and female patients with pattern hair loss based on anecdotal experience.[12] LLLT was proposed to accelerate mitosis and may stimulate stem cells or activate keratinocytes of hair follicles. In addition, laser light can alter cell metabolism by photodissociation of inhibitory nitric oxide from cytochrome c oxidase (unit IV in the mitochondrial respiratory chain), resulting in increased production of ATP and cell activity.[13] Previous studies suggested the benefits of the 1540-nm fractional laser for alopecia treatment. By using a fractional near-infrared laser, the depth of penetration and the size of the wound can be easily controlled, making invisible wounds without bleeding.[14]

1.1 | Aim of study

To evaluate the safety and efficacy of 1540-nm fractional erbium-glass laser in the treatment of AGA.

2 | PATIENTS AND METHODS

The study was a clinical trial for outpatients from Department of Dermatology and Venereology of Al-Sadder Teaching Hospital, Najaf/Iraq, and the laser treatment was done in laser research unit/Faculty of Medicine/University of Kufa in the period extending from January 2015 to December 2015.

The ethical approval was obtained from the Scientific Council of Dermatology and Venereology—Arab Board of Medical Specializations. All the patients were given written informed consent after understanding the nature of the trial.

The total number of androgenic alopecia patients participated in the present study was 51 patients, 25 men, and 26 women. A full medical history was taken stressing on the duration, severity, pattern of hair loss, family history of alopecia, drug history, and gynecological history for female patients. A full scalp examination for pattern and stage of androgenic alopecia was done.

2.1 | Inclusion criteria

- Good health status.
- Norwood-Hamilton classification of 2, 3, 4, and 5 for men and Sinclair scale of 2, 3, 4, and 5 for women.

2.2 | Exclusion criteria

- Active infection or scarring of the skin in the scalp.
- Pregnancy.
- History of poor wound healing.
- Patients with the chronic skin disease of the scalp.
- Patients had a pacemaker.
- Patients did transplantation of hair or scalp reduction.
- Patients used minoxidil 6 months before laser therapy.
- Patients had taken the following drugs during the last 6 months before starting laser therapy: finasteride, medications with anti-androgenic properties (eg, spironolactone, cyproterone acetate, ketoconazole), anabolic steroids, and medications that can potentially cause hypertrichosis (cyclosporine, phenytoin).

A "Target site" in the affected area of scalp was chosen as (1 × 1 cm^2). The hairs within this target site were clipped. Then, the target site was marked with a semi-permanent ink pen and photographed using Sony digital high sensitivity, 9.1 megapixels, DSC-HCI still camera. This procedure was done at baseline and after the end of the study.

The photograph was computerized and magnified 5× its original size, and the numbers of terminal hairs were calculated at baseline and after the end of the study. The diameter of the hairs gained from the shaved target site and the average diameter of five hair clipped from the target site were recorded before and after treatment. The diameter was assessed by using digital microscopy (color CMOS, sensor, high-speed DSP, resolution 640&480, 5× Digital Room, China) with 50× magnification.

The patients have received 10 treatment sessions with 1540-nm fractional erbium-glass laser (Quanta System SPA DNA Laser Technology), at 2-week intervals using the fixed parameters (7 mm tip, 6 mJ pulse energy, 1 HZ frequency). The laser was irradiated with only one pass. In each treatment session, the pulse energy delivered per unit area was similar. The total area of alopecia was treated. Any adverse effect was reported during the study period.

2.3 | Efficacy evaluation

2.3.1 | Objectively

The changes in the density of terminal hair (hair count/cm^2) and the diameter of the hair shaft in the target site were evaluated before

treatment and at end of the study from baseline. Assessment by two independent dermatologists was based on interpretation of photographs before and after treatment using a global evaluation scale of 7 points: slightly increased (+1), moderately increased (+2), significantly increased (+3), no change (0), slightly decreased (−1), moderately decreased (−2), and significantly decreased (−3).

2.3.2 | Subjectively

Using the 7-point scale previously described, patients also scored their satisfaction with the overall treatment outcome. Adverse effects to the laser treatment including erythema, erosion, edema, dryness, pruritus, and broken hair shaft were evaluated at each visit.

The statistical analysis was carried out using SPSS (Statistical Package for the Social Sciences) version 20, in which we use chi-square for categorical data and paired sample *t* test for numerical data. *P*-value ≤ .05 was regarded significant.

3 | RESULTS

Fifty-one patients were included in this study, 26 women and 25 men. Four patients defaulted from the study: one woman after 2nd session because she had new pregnancy and three men after 4th session due to unknown causes. The total number of the patients who completed laser treatment was 47 subjects, 25 were women (53.2%) and 22 were men (46.8%). The ages of the patients ranged between 20 and 40 years with a mean age of (30 ± 10 SD) years, and the majority of treated patients (63%) were between 26 and 35 years (Table 1). Fifteen women (60%) and 18 men (81.8%) had a positive family history of androgenic alopecia.

3.1 | Evaluation

3.1.1 | Objective

Change in hair density

In women with AGA, the changes in mean hair density/cm^2 between the initial visit and at the end of follow-up were statistically significant where the *P*-value was .006, .023, .034, and .037 for stages 2, 3, 4, and 5 respectively. In male patients, the results were statically significant for stages 2, 3, and 4 where the *P*-value was .018, .003, and .002, respectively, and insignificant for stage 5 (*P*-value was .099; Table 1).

Change in hair thickness

Regarding changes in hair shaft diameter in women before treatment and 5 months after treatment, there was significant statistical difference where *P*-value was .001, .001, .010, and .034 for stages 2, 3, 4, and 5, respectively. In male patients, there were statistically significant changes for stages 2, 3, and 4 where *P*-value was .003, .001, and .012, respectively, with an insignificant difference for stage 5 where *P*-value was .084 (Table 2). The total number of the patients showed a statistically significant difference regarding the hair density and hair shaft diameter before and after treatment with laser (*P*-value .001; Table 3; Figure 1).

TABLE 1 Hair density at baseline and 5 mo after 1540-nm fractional erbium-glass laser

	Hair density/cm^2		
	Baseline (mean ± SD)	After 5 mo of laser treatment (mean ± SD)	*P*-value
Women			
Stage 2	98.57 ± 1.9	116.57 ± 12.7	.006*
Stage 3	80.85 ± 7.9	90 ± 8.64	.023*
Stage 4	57 ± 4.18	65.5 ± 4.6	.034*
Stage 5	44 ± 3.16	47.6 ± 3.57	.037*
Men			
Stage 2	82 ± 13	92.2 ± 16.8	.018*
Stage 3	63.3 ± 3.2	72.3 ± 3.2	.003*
Stage 4	53 ± 3.94	61 ± 7	.002*
Stage 5	39.6 ± 2.6	41.2 ± 1.09	.099

*Significant (*P*-value < .05).

3.1.2 | Investigator assessments

After 5 months of treatment, each patient was assessed by two independent dermatologists by means of a 7-point scale of global photograph that showed improvement in 17 women (68%) [seven (28%) had mild response, 9 (36%) moderate response, and one (4%) excellent response], seven women (28%) stabilized (no response), and one woman (4%) reported to have slightly worse response. Ten men (45%) showed improvement [5 (22.75%) had mild improvement, 4 (18.18%) moderate improvement, and 1 (4.5%) reported to have excellent improvement], 11 men (50%) stabilized (no response), and 1 man (4.5%) reported to have bad response (more hair loss).

3.1.3 | Patient self-assessment

Using self-administered questionnaire, in general all patients reported stabilized hair shedding, 19 women (76%) showed satisfaction[with 8 (32%) mild satisfaction, 8 (32%) moderate satisfaction, and 3 (12%) excellent satisfaction]; 6 (24%) not satisfied (stabilized), and no one became worse, while 16 men (72%) gave a response [9 (40%) mild satisfaction, 6 (27.5%) moderate satisfaction, and 1 (4.5%) excellent satisfaction]; 6 men (27.5%) are not satisfied (stabilized), and no one became worse.

Most improvements of hair loss were noticed in men with the frontovertical presentation, while the most resistant site was a bitemporal recession.

3.1.4 | Side effects

No significant adverse effects during treatment had been noticed. One patient developed mild erosion after the 7th session resolved

without sequelae; two patients reported mild erythema resolved spontaneously within 1 day, and two patients reported burning sensation in the treated area that resolved within hours.

4 | DISCUSSION

Generally, treatment objectives of androgenic alopecia increased the scalp's hair coverage and delay further hair thinning by taking the drugs such as minoxidil, finasteride, and dutasteride,[15-26] and occasionally, surgery[27] is used to treat male hair loss patterns, but conventional medical treatments usually only produce slightly satisfactory results. In addition, hair transplantation has limitations, as it is invasive, expensive, and not ideal for patients in the early stage.

The potential role of laser light treatments for male and female hair loss has been of great interest.[12,27] Paradoxical hair growth following removal by laser is an example of photo-induced hair growth.[28-31] Observations for some 50 years ago indicated that some new hair follicles were formed in rabbits, mice, and humans after wounding.[32,33]

Compared with other laser systems, a 1540-nm fractional erbium-glass laser system has many advantages over other lasers, including regulation of penetration depth and wound size; wounds are small and invisible, without bleeding, and cause less damage to terminal hairs.[14]

Kim et al used a 1550-nm fractional erbium-glass laser to create micro-coagulative dermal wounds. They showed that hair growth and hair cycle modulation in C3H mice could be achieved by using 1550-nm MOSAIC fractional erbium-glass laser photothermolysis treatment in the animal model.[34]

A number of possible laser irradiation physiological mechanisms can play a role in improving hair growth, including increased blood flow, promotion of anagen hair growth, and enhanced transformation of the telogen to anagen phase.[35-37]

The fractional erbium-glass laser wounding induced an increment of blood flow, cytokines, and growth factor changes.[38] Many

TABLE 2 Hair shaft diameter in millimeter (mm) at baseline and 5 mo after 1540-nm fractional erbium-glass laser

	Baseline (mean ± SD)	After 5 mo of laser treatment (mean ± SD)	*P*-value
Women			
Stage 2	3.21 ± 0.39	4.21 ± 0.48	.001*
Stage 3	3.28 ± 0.48	3.92 ± 0.53	.001*
Stage 4	3 ± 0.44	3.66 ± 0.25	.010*
Stage 5	2.9 ± 0.41	3.4 ± 0.41	.034*
Men			
Stage 2	3.4 ± 0.22	4.2 ± 0.44	.003*
Stage 3	2.6 ± 0.51	3.4 ± 0.37	.001*
Stage 4	2.5 ± 0.44	3 ± 0.44	.012*
Stage 5	2 ± 0.27	2.2 ± 0.41	.084

*Significant (*P*-value < .05).

TABLE 3 Hair density and hair shaft diameter before and 5 mo after laser treatment among men and women

	Baseline (mean ± SD)	After 5 mo of laser treatment (mean ± SD)	Mean changes (%)	*P*-value
Women				
Hair density	72.8 ± 21.58	83.08 ± 27.32	10.12 (14%)	.001*
Hair shaft diameter	3.12 ± 0.43	3.84 ± 0.51	0.72 (23%)	.001*
Men				
Hair density	59.36 ± 16.46	66.68 ± 19.91	7.32 (12.3%)	.001*
Hair shaft diameter	2.68 ± 0.56	3.29 ± 0.7	0.61 (22.7%)	.001*

*Significant (*P*-value < .05).

FIGURE 1 Twenty-nine-year-old man with significant improvement at baseline (A) and 5 mo after laser treatment (B)

molecular manipulators in wound healing, including members of the FGF family, EGF, IGFs, HGF, TGF-b, VEGF, NGF, and interleukins, are also known as key factors of hair growth and the hair cycle.[39] So, the changes in cytokines and growth factors might have an important position in the pathogenesis of 1540-nm fractional erbium-glass laser–induced hair growth stimulation and hair cycle progress, especially, Wnt, B-catenin, and Lef1 signaling.[14,40,41]

Lee et al noted the effect of a 1550-nm fractional erbium-glass laser in women with androgenetic alopecia. The mean changes in hair density between baseline and after laser treatment were 57/cm^2 (57%), and mean changes in hair thickness were 17 μm (77%). The photographs showed improvement in 24 (87.5%) of the 27 patients.[42] However, the present study in comparison with Lee et al study enrolled both male and female subjects, with more advanced stages (2-5). These are acceptable results with regard to more advanced stages in our patients and suggested that earlier initiation of the laser treatment had the greatest benefit from treatment.

A randomized, double-blind LLLT controlled trial was conducted by Kim et al using a helmet-type device consisting of laser diodes emitting wavelengths of 650 nm. Results showed a significant mean difference from baseline for hair density (mean increase hair density 17.2 cm^2); no significant difference in hair shaft diameter and in subjective assessments of hair growth was found.[43] In comparison with the present study showed reference mean hair thickness with significant clinical photographs improvement suggested that increase in hair thickness was important for noticeable improvement: These results explained that fractional erbium-glass laser may overcome LLLT to induce increase in hair thickness in addition to the increase in hair density plus favorable compliance of patients to use at 2-week intervals in our study rather than daily treatment with LLLT.

A study assessed the high efficacy of treating male AGA using at a 655-nm wavelength low-level laser device, called TOPHAT, in a randomized, double-blind, controlled trial,[44] resulting in a significant improvement in patients who used the device. Specifically, there was a 35% increase in terminal hair counts in the in male patients who were 18-48 years of age and had II-V Hamilton-Norwood baldness pattern, and no significant change in hair shaft diameter was found. Our study showed lower percent of increment of hair density in male subjects; however, the patients in the present study had a significant increase in hair shaft diameter. The laser's dose rates per treatment in the TOPHAT study were much higher (there were 215-mW laser units) as well as the number of treatment sessions.

5 | CONCLUSION

The 1540-nm fractional erbium-glass laser seems to be an effective and safe treatment option for women and men with androgenic alopecia. In addition, the improvement was achieved in a short period.

6 | RECOMMENDATIONS

1. Low-energy protocol at 2-week interval seems to be a suitable protocol for the treatment of androgenic alopecia, so recommend to use this protocol in further studies using this type of laser.
2. Evaluate the efficacy and safety of 1540-nm fractional erbium-glass laser in other types of hair loss such as alopecia areata.

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