ORIGINAL ARTICLE

The effect of a 1550 nm fractional erbium–glass laser in female pattern hair loss

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Abstract

Background Female pattern hair loss (FPHL) is the most common cause of hair loss in women, and its prevalence increases with advancing age. Affected women may experience psychological distress and social withdrawal. A variety of laser and light sources have been tried for treatment of hair loss, and some success has been reported.

Objective The purpose of this study was to determine the efficacy and safety of a 1550 nm fractional erbium–glass laser in treatment of female pattern hair loss.

Patients and methods Twenty eight ethnic South Korean patients with varying degrees of FPHL were enrolled in the study. Patients received ten treatments with a 1550 nm fractional Er:Glass Laser (Mosaic, Lutronic Co., Ltd, Seoul, South Korea) at 2-weeks intervals using the same parameters (5–10 mm tip, 6 mJ pulse energy, 800 spot/cm² density, static mode). Phototrichogram and global photographs were taken at baseline and at the end of laser treatment, and analysed for changes in hair density and hair shaft diameter. Global photographs underwent blinded review by three independent dermatologists using a 7-point scale. Patients also answered questionnaires assessing hair growth throughout the study. All adverse effects were reported during the study.

Results Twenty seven patients completed a 5-month schedule of laser treatment. One patient was excluded during treatment due to occurrence of alopecia areata. At the initial visit, mean hair density was 100 ± 14/cm², and mean hair thickness was 58 ± 12 μm. After 5 months of laser treatment, hair density showed a marked increase to 157 ± 28/cm² (P<0.001), and hair thickness also increased to 75 ± 13 μm (P<0.001). Global photographs showed improvement in 24 (87.5%) of the 27 patients. Two patients (7.4%) reported mild pruritus after laser treatment; however, these resolved within 2 h.

Conclusion A 1550 nm fractional erbium–glass laser irradiation may be an effective and safe treatment option for women with female pattern hair loss.

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Conflict of interest None declared.

Introduction

Female pattern hair loss (FPHL) is the most common cause of hair loss in women and its prevalence increases with advancing age. Due to the uncertain correlation between androgens and this entity, FPHL has emerged as the preferred term for androgenic alopecia in women. It is characterized by diffuse loss of hair of the parietal or frontotemporal regions with retention of the frontal hairline. The pattern of hair loss in women is different from that of men in that the former shows less pronounced recession of hair line and rarely shows vertex balding. Prevalence increases with age, from approximately 12% among women between the ages of 20 and 29 years to over 50% of women over the age of 80. Paik et al. reported a prevalence of AGA of 5.6% in Korean women, which was lower than that in Caucasians, as reported in the literature. FPHL is less prominent than male pattern hair loss; however, it can cause greater psychosocial distress and severe impairment of social function than in men. Conventional medical treatments are usually unsatisfactory and surgical hair transplantation is invasive, expensive and not good for early stage FPHL. Many mechanical stimulants cause local adverse problems, including pain, bleeding, burn or immediate hair loss.

Laser and light sources have been popular over the past few years in both medical and non-medical settings. Photobiomodulation is the term commonly used to describe the effect of lower-level light energy on the cellular level. Consensus shows that low-level laser therapy (LLLT) appears to be safe and effective for use in treatment of male and female pattern hair loss; however, the evidence remains relatively non-scientific. A variety of LLLT have been tried for hair loss, including the excimer laser, He-Ne laser and PUVA, and some success has been reported.
low-level lasers but also high-energy lasers have been tried for treatment of hair loss. Paradoxical hair growth after laser treatment with intense pulsed light, diode laser or long-pulse alexandrite laser has been reported. 10–13 The causal relationship of laser treatment and hair growth is not clear; however, there is evidence to support that laser irradiation might hold potential for use in treatment of alopecia. These observations led us to search for what type of laser might be most suitable for use in treatment of alopecia.

The purpose of this study was to evaluate the clinical efficacy and safety of the 1550 nm fractional erbium–glass laser in women with FPHL.

**Patients and methods**

Twenty eight ethnic South Korean female patients with varying degrees of FPHL were enrolled in the study at the Department of Dermatology, Kangbuk Samsung Hospital between March 2010 and September 2010. Of the 26 patients initially enrolled, 27 completed the study; one patient developed alopecia areata at the third laser treatment and dropped out. Patients ranged in age from 26 to 55 years (mean 41.8 years) and Ludwig classification ranged from I \((n = 16; 59.3\%\) ) and II \((n = 11; 40.7\%\) ) (Table 1). All patients were females, aged 26–55, with Ludwig classification I–II. Before inclusion in the study, all patients provided written informed consents. Patients who had suffered from systemic disease in the recent 6 months were excluded. Patients who had undergone treatment with any medication that can affect the hair cycle within 3 months; patients who had undergone treatment for alopecia using surgical methods, such as hair transplantation; and pregnant and lactating women were excluded. Alopecia other than female pattern hair loss, such as alopecia areata, telogen effluvium was also excluded. All patients underwent normal androgen, iron, zinc, FANA, rheumatic factors and normal thyroid function tests at the initial screening. Patients with abnormal blood tests were excluded. This study was designed as a single-centre, prospective, single-blinded, controlled trial, and has been approved by Kangbuk Samsung Hospital’s IRB (Institutional review board). In this study, we used a 1550 nm fractional erbium–glass laser (MOSAIC, Lutronic Corporation, Seoul, South Korea). Each patient received 10 treatments at 2-week interval. As no laser parameters have been established for alopecia, suitable parameters (5–10 mm tip, 6 mJ pulse energy, 800 spot/cm² density, static mode) for the study were determined based on comparison of results of preliminary experiments using various parameters, such as high energy with low density or low energy with high density (data not shown). The laser was irradiated with only one pass. The delivered pulse energy per unit area for each woman and each treatment session was similar. We treated the whole diffuse alopecic area, usually involving the frontovertical and parietal regions. There was no need to shave whole hair for the laser treatment. With the laser treatment, we could not observe any damage to the hair itself, for example broken hair shaft. The only small area for phototrichogram was shaved and this area was also included for treatment. After laser treatment, definite erythema developed at all treatment sites. No topical anaesthetics or analgesics were necessary during the treatment phase.

High resolution digital photographs were taken using a Nikon DSLR camera (Nikon, Tokyo, Japan) and phototrichogram (Folli-scope; LeadM, Seoul, Korea) prior to and at the end of treatment. Effectiveness of treatment was evaluated using two forms of objective assessment: a phototrichogram measurement and an interpretation of global photographs by three independent dermatologists. The phototrichogram assessment area was selected in the relatively severe alopecic region, usually vertex. For the phototrichogram assessment, the selected area was shaved in a 10 mm-diametered round shape at the pre- and post-treatment time. We have tattooed the shaved phototrichogram sites for reproducibility. The phototrichogram evaluation was based on the grade of hair density and hair shaft diameter. The change of shaved scalp hair density between the pre- and post-treatment state was compared. With the hairs gained from the shaving of the assessment area, the average diameter of four to five hair shafts of the pre- and post-treatment state was also compared. Also, the difference of hair density and thickness changes between pre- and post-menopausal women was evaluated. Assessment by physicians was based on interpretation of before and after photographs of treatment using a 7-point global assessment scale; significantly decreased \((-3\) ), moderately decreased \((-2\) ), slightly decreased \((-1\) ), no change \((0\) ), slightly increased \((+1\) ), moderately increased \((+2\) ) and significantly increased \((+3\) ). These three independent physicians were blinded to treatment group. Patients also scored their satisfaction with the overall treatment outcome using the 7-point scale previously described herein. At each visit, medical examination and adverse effects related to laser treatment, including erythema, erosion, oedema, seborrhoeic dermatitis, dryness, pruritus and broken hair shaft were registered at any time.

SPSS statistical package (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. Significances of changes in hair density and thickness were determined using the paired T-test. Significance of difference in clinical improvements between pre- and post-menopause groups was analysed using repeated measure ANOVA test. Statistical significance was accepted for P-values less than 0.05.

Table 1 Characteristics of 28 women with female pattern hair loss

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>Mean age ± SD</td>
<td>41.8 ± 1.96 (26–55 years)</td>
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<tr>
<td>Familial history of hair loss</td>
<td>22/28 (78%)</td>
</tr>
<tr>
<td>Menopausal state</td>
<td></td>
</tr>
<tr>
<td>Pre-menopausal women</td>
<td>12/28 (42%)</td>
</tr>
<tr>
<td>Post-menopausal women</td>
<td>16/28 (58%)</td>
</tr>
<tr>
<td>Ludwig score</td>
<td></td>
</tr>
<tr>
<td>I (mild)</td>
<td>16/28 (58%)</td>
</tr>
<tr>
<td>II (moderate)</td>
<td>12/28 (42%)</td>
</tr>
</tbody>
</table>
Results
At the initial visit, mean hair density was 100 ± 14/cm² and mean hair thickness was 58 ± 12 μm. After 5 months of laser treatment, hair density showed a marked increase to 157 ± 28/cm² (P < 0.001), and hair thickness also increased to 75 ± 13 μm (P < 0.001) (Table 2, Figs 1 and 2). Although all patients in both pre- and post-menopause patients showed overall clinical improvement, there was no statistically significant difference in treatment efficacy between two groups (P = 0.553) (Table 3). Global photographs showed improvement in 24 (87.5%) of the 27 patients. Among them, three (12.5%) showed significant change and 21 (75%) showed moderate improvement; however, three (12.5%) showed a stabilized state. Of particular interest, remarkable improvement at the frontal hair recess was seen in all patients. Using the self-administered questionnaire, 26 (92.3%) patients judged their condition as improved and one (3.7%) as stabilized. None of the patients reported that their condition had worsened (Table 4, Figs 3 and 4). No significant adverse effects, such as erythema, erosion, oedema, seborrheic dermatitis, dryness or broken hair shaft during laser treatment were observed. Two patients (7.4%) reported mild pruritus with a burning sensation on the treated area after laser treatment; however, these resolved within 2 h without complication. All patients showed good tolerance for treatment-related pain.

Discussion
The relationship between skin wounding and hair growth has been a main research area of interest. Stimulation of hair follicle growth or acceleration of hair cycling in the skin after wounding has been discussed for many years.14–16 Ito et al. demonstrated de novo formation of hair follicles after wounding in genetically normal adult mice. Regenerated hair follicles establish a stem cell population, express known molecular markers of follicle differenti-

Table 2 Phototrichogram assessment of hair density and thickness

<table>
<thead>
<tr>
<th></th>
<th>Hair density (mg/cm²)</th>
<th>Hair shaft thickness (μm)</th>
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<tbody>
<tr>
<td>Baseline</td>
<td>100 ± 14</td>
<td>58 ± 12</td>
</tr>
<tr>
<td>After 10 times laser treatment</td>
<td>157 ± 28</td>
<td>75 ± 13</td>
</tr>
<tr>
<td>Mean % change from baseline</td>
<td>57%</td>
<td>77%</td>
</tr>
<tr>
<td>P-value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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</tbody>
</table>

Table 3 Changes of hair density and thickness between pre- and post-menopausal women

<table>
<thead>
<tr>
<th></th>
<th>Average of increased hair density</th>
<th>Average of increased hair thickness (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-menopausal women</td>
<td>59.17 ± 16.63/cm²</td>
<td>16.10 ± 9.5</td>
</tr>
<tr>
<td>Post-menopausal women</td>
<td>55.07 ± 23.8/cm²</td>
<td>17.70 ± 5.6</td>
</tr>
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</table>

Table 4 Patient and investigator assessments of FPHL after 10 laser treatments

<table>
<thead>
<tr>
<th></th>
<th>Patient assessment (questionnaire)</th>
<th>Investigator assessment (GPA)</th>
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<tr>
<td>Improvement (+1, +2, +3)</td>
<td>26 (92.3%)</td>
<td>24 (87.5%)</td>
</tr>
<tr>
<td>Stabilization (0)</td>
<td>1 (3.7%)</td>
<td>3 (12.5%)</td>
</tr>
<tr>
<td>Worsening (−1, −2, −3)</td>
<td>None</td>
<td>None</td>
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FPHL, female pattern hair loss; GPA, global photography assessment.
Fractional photothermolysis is a recently introduced laser treatment that creates numerous microscopic thermal injury zones of controlled width, depth and density that are surrounded by a reservoir of spared epidermal and dermal tissue, allowing for rapid repair of laser-induced thermal injury. We proceeded with the hypothesis that a fractional laser, with proper modulation of the hair cycle and acceleration of hair follicle formation and cycling in mice. Semenova et al. reported that overexpression of mIGF-1 in keratinocytes resulted in improved wound healing and accelerated hair follicle formation and cycling in mice.

Low-level light therapy has been approved by the FDA as a treatment option for hair loss. Avram et al. reported an increase in the number of terminal hairs and hair shaft diameter and a decrease in the number of vellus hairs after LLLT treatment. As mentioned above, several high-energy lasers also showed high potential for use in treatment of alopecia. We then supposed that the fractional laser as a wounding source might have a stimulating effect for hair growth.

Fractional photothermolysis is a recently introduced laser treatment that creates numerous microscopic thermal injury zones of controlled width, depth and density that are surrounded by a reservoir of spared epidermal and dermal tissue, allowing for rapid repair of laser-induced thermal injury. We proceeded with the study based on the hypothesis that a fractional laser, with proper application, could cause proper wounding and show a treatment effect for alopecia. In a preliminary study, we demonstrated the effectiveness of the fractional laser in both hair growth and modulation of the hair cycle in an alopecic mouse model. In an animal study, conversion to anagen hair was revealed by histological evaluation and the change of molecular signals associated with the hair cycle, such as Wnt 5a, b-catenin using molecular analysis (data not shown).

In our study, fractional laser treatment induced a significant increase of hair density and hair shaft thickness. Two patients showed 100% increment of hair density (Fig. 1). These improvements might be explained by hair growth stimulation by vellus to terminal transformation and accelerated hair cycle progress. The fractional laser wounding induced-increased blood flow, cytokines and growth factors changes, or direct stimulation of dermal papilla might be the underlying pathogenic mechanism. Many molecular manipulators in wound healing, including members of the FGF family, EGF, IGFs, HGF, TGF-β, VEGF, NGF and interleukins, are also known as key factors of hair growth and the hair cycle.

So, the changes of cytokines and growth factors might have an important position in the pathogenesis of fractional laser-induced hair growth stimulation and hair cycle progress: especially, Wnt-β-Catenin-LeF1 signalling.

Laser and light-based treatment in FPHL is a potentially attractive treatment modality. In particular, it is an appropriate alternative for treatment of patients with FPHL who have not responded to previous treatment or in whom systemic treatment is contraindicated. A fractional 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.

In conclusion, the 1550 nm fractional erbium–glass laser may be an effective and safe treatment option for women with FPHL. Also, improvement was achieved in a short period. Combined therapy with conventional treatments, such as topical minoxidil and systemic medication, could have a synergistic effect for FPHL. This study has some limitations because we were not able to prove the exact mechanism or propose more suitable parameters and treatment intervals.

**References**