

# Selective Photothermolysis of Hair Follicles by Normal-mode Ruby Laser Treatment

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**This study was designed to evaluate the effect of selective photothermolysis on dark pigmented hair follicles treated with a normal-mode ruby laser (694-nm wavelength, pulse duration 0.5 ms, fluence 20 J/cm<sup>2</sup>, spot size 2 mm). In 15 volunteers, four test areas each were selected. After shaving, the first area was irradiated once, the second twice, the third three times and the fourth served as control area. A punch biopsy was taken from each volunteer immediately after the first laser treatment. Four weeks after the last irradiation, no effect was found in six cases and little effect in another six cases (50–90% regrowth). Hair regrowth of less than 30% was observed in only three cases. Eight weeks after the last session, no effect was found in 11 cases, little effect in 2 cases (10%) and less than 30% regrowth in only 2 cases. Twelve weeks after the last treatment, no difference could be detected between the areas untreated and treated by laser. The laser parameters applied in this study do not result in effective epilation of body hair. In some cases, a delay in growth of several weeks was noticed. Key words: laser epilation; long-term effect; delay in growth; ruby laser.**

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Many patients, especially females, complain of problems regarding excess hair growth (hypertrichosis, hirsutism or virilism). In children, simple hypertrichosis may also be very disturbing. In idiopathic cases, treatment can only be symptomatic. Local external measures such as shaving, plucking, cold- or hot-wax epilation or chemical depilatories have only temporary effect. Different methods of electroepilation can achieve permanent hair follicle destruction, but this treatment can be painful, tedious and time-consuming, and may have side effects such as folliculitis and scarring.

Recently, a study has been performed by Grossman et al. (1) to investigate the effects of a high-power ruby laser on hair follicles. The aim of our study is to evaluate the epilation capability of a normal-mode ruby laser with limited energy density.

## MATERIAL AND METHODS

### *Patients and study design*

Seven female and 8 male volunteers (aged 20–38 years) with skin types II or III and normal hair growth on the upper thighs (7 males), the lower legs (7 females) and the lower back (1 male) were included in the study. The hair colour was black or dark brown, and since the study was performed in winter, the skin areas were not suntanned. An area measuring 9 × 6 cm was shaved completely and subdivided into two

halves. The first half was used as a control area not to be exposed to laser therapy, whereas the second half served as the actual test area, further subdivided into three equal segments (A, B and C). These three segments were exposed to the following laser therapy at one-week intervals: segment C was exposed only once, segment B was exposed twice and segment A thrice. Prior to each exposure, both control and test areas were completely shaven. Follow-up visits took place one, two and three months after the last irradiation.

### *Laser treatment parameters*

A non-q-switched (normal-mode) ruby laser (MELTEMI, Fa. NWL, Heroldsberg, Germany) was used to irradiate the test areas with a fluence of 20 J/cm<sup>2</sup>, a spot size of 2-mm, pulse duration of about 0.5 ms and a wavelength of 694 nm. Pulses were positioned in an overlapping manner to assure homogeneous irradiation of the entire area.

### *Skin biopsy sampling and processing*

In each volunteer, a hairy area of about 1 cm<sup>2</sup> outside the test areas was marked and exposed once to ruby laser irradiation, as described above. The center, showing at least one hair, was biopsied using a 4-mm biopsy punch immediately after the laser treatment. The specimen was instantly frozen, stored at –70°C and stained with nitroblue tetrazolium chloride. This histochemical method was introduced by Neumann et al. (2) for investigating laser tissue effects as shown by Hohenleutner et al. (3).

### *Evaluation*

The irradiated test area was compared to the shaved control area. We made an approximate estimation with the help of photos. The regrowth of hair in the areas treated by laser was evaluated in comparison to the regrowth in the shaved part.

## RESULTS

### *Clinical outcome after normal-mode ruby laser treatment*

*Upper thigh (n=7).* After 4 weeks, a regrowth rate of less than 30% was seen in 3 cases and in only 2 cases after 8 weeks. Twelve weeks after the last treatment, a total regrowth in each of the 7 cases was noticed. The hair colour was dark brown in the 2 cases showing best results. A difference between the areas treated once, twice and thrice was detectable in only 3 cases: regrowth of less than 10% (*n*=2) and 20% (*n*=1) in the area treated three times compared to 50% (*n*=2) and 80% (*n*=1) in the area treated only once. However, after 2 months, hair growth in these cases was similar in both the test and control areas.

*Lower leg (n=7).* In most cases, no difference between the control area and areas treated by laser could be detected. In only one patient, regrowth reduced by 10% was observed after 4 weeks. After 8 weeks, total regrowth was present in all 7 cases.

*Sacral (n=1).* In this single patient, growth was reduced by about 10% after 4 weeks, with no difference between the laser and control areas after 8 weeks.

*Side effects*

Some of the patients, especially males when treated on the upper thigh, complained about a pricking sensation during treatment. No erythema was seen after the irradiation. Side effects such as scars, hyper- or hypopigmentation or hair discoloration did not occur.

*Histopathological examination*

After nitroblue tetrazolium chloride staining, normal hair follicle structures were observed in all cases. Unstained cells as proof of thermal damage, either in the epidermis, dermis or hair follicle, were not found.

## DISCUSSION

Selective photothermolysis, as described by Anderson & Parrish (4), is a method in which target structures are selectively destroyed by laser pulses. Highly selective target damage can be expected if the pulse duration is less than the approximate thermal relaxation time of the target chromophore. Apart from heating the target structure, one effect of this treatment can be that the directly surrounding tissue can be damaged thermally by heat conduction (5).

The ruby laser emits light at 694 nm. This wavelength penetrates relatively deeply into the dermis, and is better absorbed by melanin (melanosomes) than by other structures in the skin. Thus, selective photothermolysis by ruby laser treatment could theoretically be an acceptable method for epilation of pigmented hair follicles. This therapy might produce good long-term results and a low incidence of side effects. For that purpose, a normal-mode ruby laser with pulses of about 0.5 ms was designed to maximize delivery of light to the reticular dermis while minimizing epidermal injury. The longer pulse duration is necessary because of the larger target structure, in contrast to the shorter pulses used in treatment of lentigines or tattoos. First clinical results seem to confirm this theory. Grossman et al. (1) conducted a human study with 13 volunteers using a normal-mode ruby laser with a wavelength of 694 nm and pulses of 270  $\mu$ sec. All subjects were treated with fluences between 30–60 J/cm<sup>2</sup> and a spot size of 6 mm on the back or posterior thigh. Before treatment, half of the area was shaved, the other half was epilated with cold wax. After 1 and 3 months, a statistical delay in growth was noticed in shaven and wax-epilated

sites at all fluences. After 6 months, an effect was only seen in shaved sites treated with 60 J/cm<sup>2</sup>. A complete regrowth was present in 5 out of 13 subjects, with 4 patients still showing less than 50%.

In this study, pre-therapeutic epilation worsened the results, probably due to the removal of the target chromophore of the follicle. This concurs with the theory of selective photothermolysis: the pigmented hair shaft seems to improve the effect of papilla destruction and growth delay. Our study aimed to evaluate if different laser parameters would lead to comparable results. But the results clearly demonstrate that a lower fluence of 20 J/cm<sup>2</sup>, a pulse duration of about 0.5 ms and a small spot size of 2 mm are insufficient for effective destruction of the hair follicle, at least in the body areas chosen for the study. The depth of the hair follicles varies on different sites of the body. Results might have been better in the moustache area, where the hair follicles are more superficial than on the legs or the back.

A larger spot size with a consecutively higher penetration depth and longer pulse duration would be desirable to obtain a more sustained and widespread heating effect on hair follicles. Current treatments of patients in our department with 20 J/cm<sup>2</sup> and a spot size of 4 mm seem to achieve more favourable results, especially in the moustache area, than those produced in our study. However, pulse durations of more than 1 ms and spot sizes of more than 5 mm are desirable. These parameters remain to be evaluated in future studies.

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