Improved Laser Hair Removal (LHR) Efficacy Using 2 ms vs 3 ms Pulse Widths

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Introduction

Energy-based hair removal predates the turn of the century. Multiple energy sources—from IPL and lasers to microwaves and radio frequency—have all been investigated as to their permanent hair reduction capabilities. Lasers have proven especially popular for hair removal and have an established track record for safety, efficacy and cost efficiencies. As a matter of course, laser hair removal (LHR) has become synonymous with permanent hair reduction.

The advantages of laser hair removal can be traced both to the Theory of Selective Photothermolysis[1] (as expressed by Drs. Anderson and Parrish) upon which their operation is based and the scalability of the laser parameters governing their actual operation, including wavelength, spot size, fluence, pulse duration and epidermal protection. Whereas Selective Photothermolysis states that specific wavelengths of light can safely target chromophores in the skin—melanin is the chromophore in laser hair removal—without damaging the surrounding tissue, modifying any of the laser parameters mentioned can result in vastly different outcomes, both for better and for worse:

- Wavelength—as defined by well-established absorption spectra[2], determines energy absorption by the targeted chromophore
- Fluence—measured in J/cm^2, is a ratio of the energy being delivered to the area over which it is delivered. All else being equal, including epidermal protection, greater fluence generally equates to greater efficacy
- Spot Size—how large an area is being treated-subject to the energy delivery
- Pulse Duration—how quickly the energy is being delivered to the skin
- Epidermal Protection—the type of cooling being applied to protect the skin from thermal damage; this includes air, contact and cryogen-cooling methodologies

While all hair removal lasers operate along the same principles, depending upon their laser parameter output specifications, not all are capable of delivering the same results.

Over time, there has been an increased interest in the dual-wavelength laser approach to LHR—specifically the 755 nm and 1064 nm wavelengths—presumably for their ability to treat all skin types with a single device. Still, a lot of performance variability remains depending on the fluence, spot size and pulse durations being delivered with either wavelength.

Dr. Anderson has also proposed and leading laser experts tend to agree[3] that shorter pulse-widths are necessary to treat thinner, finer hairs. Companies offering shorter pulse durations, like Candela which was among the first to deliver 3 ms pulse duration capabilities, promote their laser hair removal efficacy accordingly.

However, no research has been conducted to our knowledge on the efficacy of hair removal with pulses shorter than 3 ms, delivered with a stamping technique, at repetition rates up to 2 Hz.

This prospective study investigated the efficacy of a 2 ms versus a 3 ms pulse-width for 755 nm and 1064 nm wavelengths for removal of hair using Candela's newest hair removal platform, the GentleMax Pro Plus laser.

Methods

A split study was performed with the right side of the subject being treated with 2 ms pulse duration and the left side treated with 3 ms pulse durations. Spot sizes and fluences were kept consistent for both sides.

4 treatments were administered at 8-12 week intervals. Treatment regions included, axilla, back, legs, face and flanks. The treatment wavelength was determined by the treating nurse based on Fitzpatrick Skin Type. Photographs were taken before and after each treatment. There were 2 follow ups at 3 months and 6 months after the last treatment. Photographs were also taken at the follow up visits.

The type of hair targeted for treatment is detailed below:

- Fine caliber hair in subjects with Fitzpatrick Skin Type I to IV with lighter complexion but dark hair treated with a 755 nm wavelength
- Fine caliber hair in subjects with Fitzpatrick Skin Type IV to VI with dark hair treated with a 1064 nm wavelength.

Subject Population:
A total of 14 subjects completed the study. 10 subjects were treated with the 755 nm wavelength. 4 subjects were treated with the 1064 nm wavelength.

Subject Demographics:

	Number of subjects
Male	5
Female	9
Total	14

Table 1. Baseline Characteristics Distribution

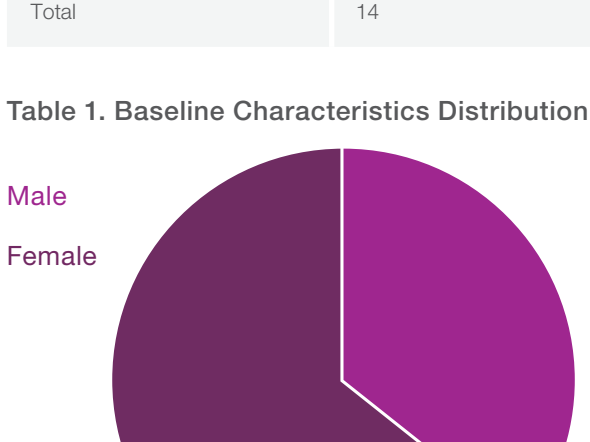

Figure 1. Subject gender

Treatment Parameters:

Fluence distribution with skin type				
	755 nm		1064 nm	
FST	Mean (J/cm^2)	Std Dev	Mean (J/cm^2)	Std Dev
I	NA	NA	NA	NA
II	20.3	4.6	NA	NA
III	19.5	0.0	25.5	3.8
IV	14.7	1.6	23.0	3.3

Table 2. Treatment parameters (Fluence according to Fitzpatrick Skin Type)

Laser Wavelength [nm]	755 nm	1064 nm
Laser pulse repetition rate [Hz]	1,1.5 or 2 Hz	1,1.5 or 2 Hz
Number of passes	1	1
Number of pulses	473±566	657±713
Spot size	12,15,18	18

Results

14 subjects completed the study and the follow-up visits in accordance with the protocol. Side effects for the treatments were mild. Perifollicular edema was observed in all cases immediately following treatment. Subjects also exhibited mild erythema. All subjects tolerated the treatments very well. No adverse events were recorded during the study.

Treatment Discomfort Level:
Following each treatment session, subjects were asked to rank their discomfort level during the treatment, using 0-10 scale (0=no pain; 10=worst pain; see Figure 2 below).

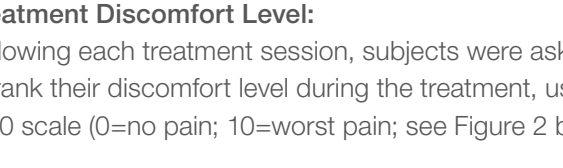

Figure 2. Numerical Scale Response (NSR)

Mean pain scores for the 755 nm treatment were 3.1±1.7 with a range of 0-8. Mean pain scores for the 1064 nm treatment were 4.9±2.1 with a range of 0-10.

The pain scores increased with subsequent treatments since the fluence levels were increased for the treatments.

Photographic Evaluation:

6 month follow-up photographs were evaluated by 4 reviewers. Reviewers were presented with image pairs (2 ms and 3 ms follow-up images) for all 14 subjects. Reviewers were asked to rate the long term reduction in hair, using a 21 point, 0-100 scale in increments of 5. Reviewers correctly picked out the 2 ms treated side in 39 out of the 44 (88.6%) image pairs presented. (11 subjects and 4 reviewers). All the reviewers correctly identified all the subjects treated with 1064 nm wavelength.

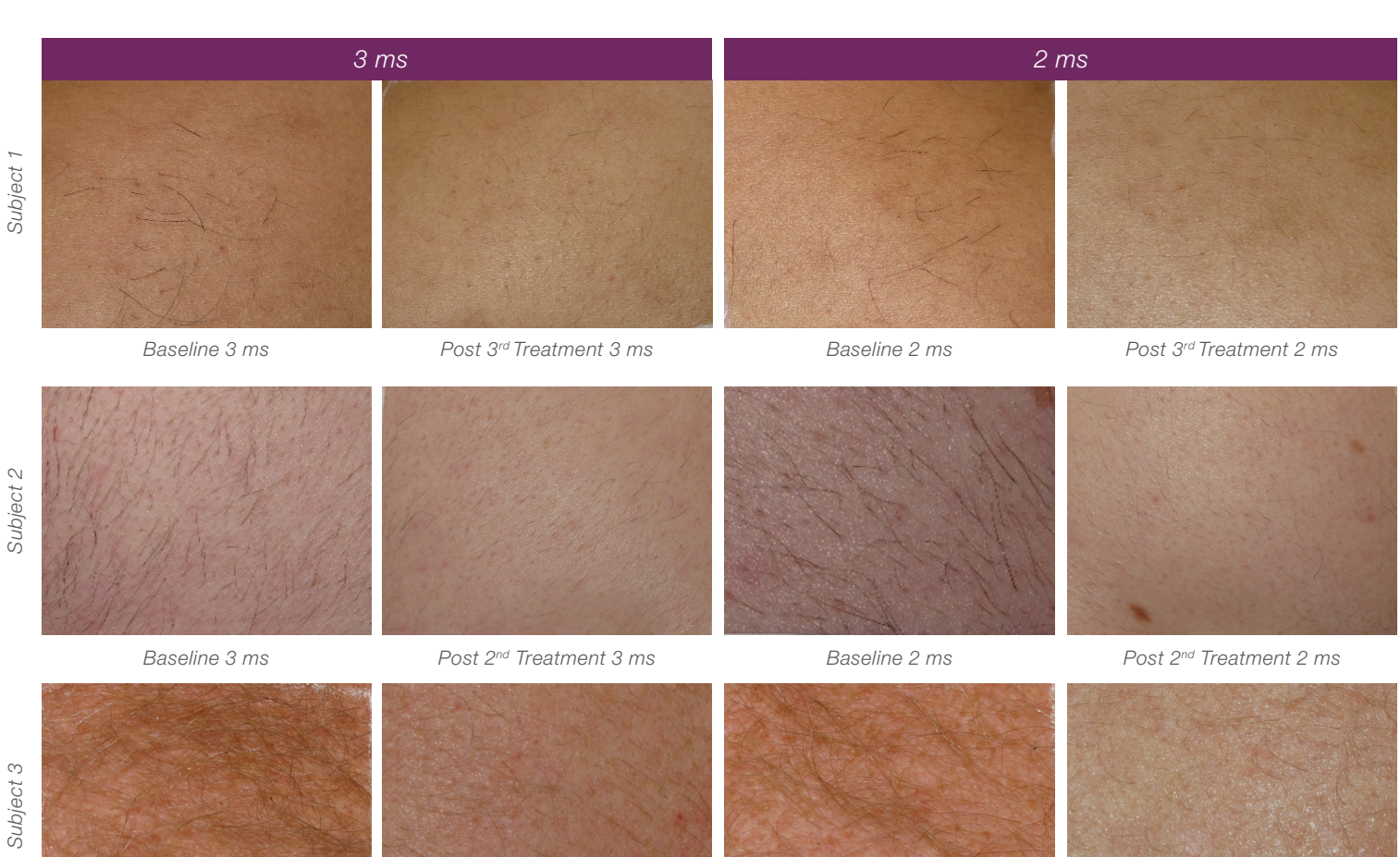

Figure 3. Before and After cases with 3 ms and 2 ms

Evaluator Identification

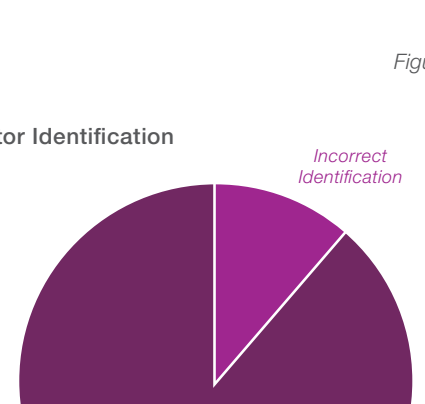

Figure 4. Evaluator Identification

Average improvement for 2 ms treated side was 58.5%.
Average improvement score for 3 ms treated side was 48.5%.

All reviewers agreed that the 2 ms treated side improved more than the 3 ms treated side.

For the 755 nm wavelength, average improvement for the 2 ms treated side was 57.3%. Average improvement score for the 3 ms treated side was 46.1%.

For the 1064 nm wavelength, average improvement for 2 ms treated side was 65.4%. The average improvement score for the 3 ms treated side was 57.1%.

A paired 2 tailed t-test was performed on the reviewer improvement scores to determine if the score difference was statistically significant. ($p<0.005$)

For the 755 nm treatment, the p value was 1.86E-11 ($p<0.005$) meaning that the two score populations are statistically different.

For the 1064 nm treatment, the p-value was 0.000109 ($p<0.005$) meaning that the two score populations are statistically different.

Discussion

In this study, the 2 ms treatment was observed to result in more effective hair reduction for fine caliber and resistant darker hair than the 3 ms treatment. This is consistent with the long-held theory that shorter pulse durations are required to consistently deliver permanent hair reduction as hair diameters decrease.

As a practical matter, Candela's recommended treatment parameters for laser hair removal typically call for the 3 ms pulse duration, although theory also allows for longer pulse durations to be used early-on in the LHR procedure when the hair follicles tend to be thicker. Even with the advent of available shorter pulse durations, this fixed 3 ms pulse duration approach may be generally maintained not only for its ease and convenience, but also for its excellent track record of success.

Again theory suggests 2 ms treatments are likely best applied at the end of the treatment regimen and when finer and resistant hairs persist. More research is required to determine when the optimal time might be to introduce 2 ms pulse duration treatments into the treatment regimen.

Of course, many factors determine laser hair removal efficacy but this study strived to limit any variations between treatments other than pulse duration. Ultimately, LHR results will always be subject to what a device can deliver in terms of all of its operating parameters including wavelength, spot size, fluence, epidermal protection and, as we have seen it this study, pulse duration.

The study concludes that the new hair removal product from Candela—the GentleMax Pro Plus—with 2 ms pulse duration treatment capabilities, represents a significant difference in laser hair removal results at both the 755 nm and the 1064 nm wavelengths for the treatment of fine, resistant hair.

[1] R. R. Anderson and J. A. Parish, "Selective photothermolysis. Precise microsurgery by selective absorption of pulsed radiation," Science 226, 524–527 (1983)
[2] Ross, E. V., & Anderson, R. R. (2013). Laser–tissue interactions. Lasers and Energy Devices for the Skin, 1-30. https://doi.org/10.3109/9781841849348.001
[3] The value of Pulse Duration and Peak Power in Laser Hair Removal and Related Applications; a roundtable Discussion of Leading Laser Experts," Candela Clinical Paper #2 (2003)

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