Basic Principles of MicroPulse Lasers

By Prof. Dr. Sascha Fauser

To understand MicroPulse laser technology, we must first understand conventional photocoagulation. In the latter, the laser beam is constantly "on" (Figure 1) and its energy is absorbed by pigmented structures. These structures are mainly melanin in the retinal pigment epithelium (RPE), but also in the choroid; some of the energy is therefore transformed into heat. The longer the laser remains on, the more heat is built up resulting in an eventual loss of transparency.

We do not yet know the exact mechanism of action of laser, but one hypothesis is that the damaged photoreceptors are replaced by glial cells, which have less oxygen consumption, less vascular endothelial growth factor (VEGF), and less edema.

Macular diseases do not necessitate a scarring process to elicit a treatment response.

And that is where MicroPulse technology begins to differentiate itself from conventional photocoagulation as it minimizes the collateral damage and results in no visible burns.

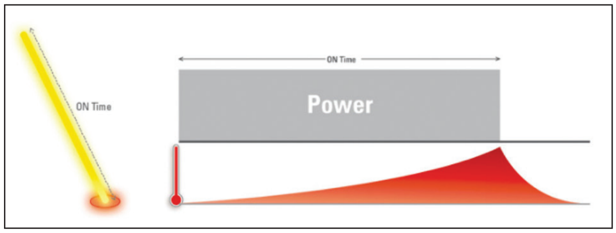

Figure 1. Conventional photocoagulation.

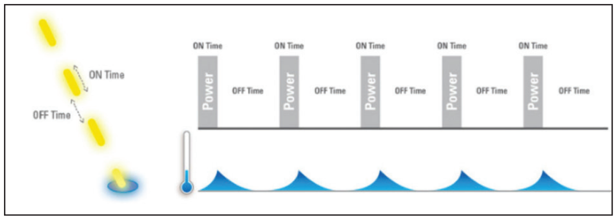

Figure 2. MicroPulse technology alternates between "on" and "off" modes.

How MicroPulse technology works

The MicroPulse laser mode delivers energy in succeeding train of very short pulses, with alternative "on" and "off" times that have led to the duty cycle concept. The duty cycle is defined as the length of time of "power on" divided by the total time the laser is used.

For example, a 5% duty cycle means that each MicroPulse of energy is "on" for 100 µs followed by 1900 µs in the "off" mode. There is a reason the laser is off much longer than it is on—we need to ensure there is enough time for the surrounding tissues to cool to eliminate the possibility of thermal damage to the inner retina. This cycle is repeated multiple times within one laser shot, ie, 100 times with a 5% duty cycle (Figure 2).

577 nm MicroPulse Laser Treatment Guidelines

By Victor Chong, MD

As with most new technology, being able to refer to a guideline can be useful; in the case of MicroPulse laser technology, there are numerous changes from traditional photocoagulation treatment that warranted a new guideline.

I have been a consultant to Quantel Medical for a couple of years, and the first time I used the MicroPulse laser was 15 years ago. We have improved it over the years as newer technology to make the procedure more efficient, easier, and safer became available to implement. Here is what led to our treatment guidelines for the MicroPulse.

Duty cycle

The literature often references duty cycle when discussing subthreshold laser therapy.[1-7]

Most publications have used a 15% duty cycle in the past, but we have found in both animal studies and clinical experience that 5% duty cycle is just as efficacious and may have an improved safety profile. So, for example, in 5% duty cycle the laser is 100 µs "on" and 1900 µs "off," as Prof. Dr. Fauser explained.

Optimal wavelength

We also know that a proper titration of the power level prior to the MicroPulse laser treatment will yield a better outcome. Determining which wavelength is optimal to achieve this titration has been a point of debate among researchers. Until recently, the only mention of wavelength in the literature was 810 nm because that had been the only technology available. The yellow 577 nm provides several advantages over earlier technology, superior absorption characteristics allowing titration of the power level in MicroPulse mode.

Multispot delivery of the MicroPulse treatment

One crucial differentiating factor that has propelled the Supra Scan 577 Laser (Quantel Medical) into my daily use is its ability to perform "multispot MicroPulse." This feature means there is no longer any reason to deliver the

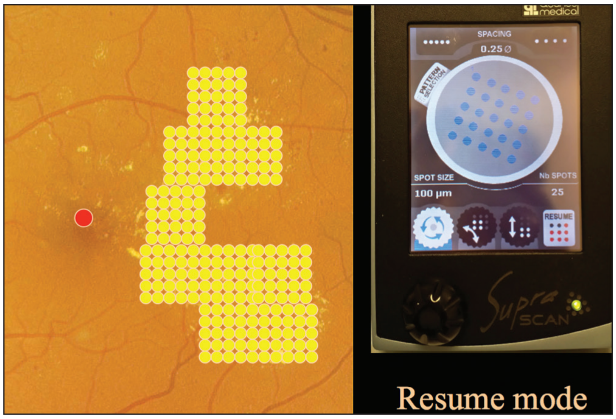

Figure 1. Combining multispot and MicroPulse technologies.

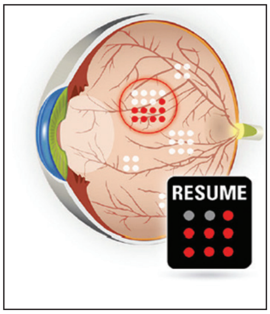

Figure 2. Resume mode.

MicroPulse laser spots manually.

Combining the MicroPulse laser technology with a mulitspot delivery system makes the overall treatment better, easier, and faster (Figure 1).

Resume mode

As MicroPulse requires long 200 ms spots (a 25-spot grid will take about 6 seconds to deliver), Quantel Medical developed the resume mode to allow for interruption and resumption of the selected pattern (Figure 2).

In resume mode, the laser shots can be fired one at a time, or the entire pattern can be fired simultaneously. The laser has a built-in safeguard so we can stop the laser if there is excessive eye movement. So, for example, if the patient has moved during the pattern delivery time and before completion, we can simply move the laser to off, adjust the patient back to the correct grid pattern, turn the laser to on and finish the pattern.

Dense treatment implementation

One of the keys to the MicroPulse laser success remains its ability to function well during dense treatment implementations (ie, confluent laser spots). This is critically important, as several early clinical studies used a non-dense treatment implementation that inadvertently led to undertreatment. Lavinsky and colleagues reinforced that belief—if we do not treat adequately, we will not get the optimal desired results.[8]

160 µm spot size

Spot size is another crucial component to delivering effective treatment. Because there is no intended thermal injury using MicroPulse, 160 µm is used to increase the treatment area, ensuring therapeutic delivery to all of the targeted tissue ("dense" treatment).

Power titrate

Some earlier research titrated the power levels using a continuous wave, activating the MicroPulse mode and adjusting the power by doubling it. This is an inherent potential limitation with the 810 nm infrared wavelength.

Thanks to the yellow 577 nm wavelength absorption characteristics, the power can be titrated in MicroPulse mode and decreased once the power level threshold has been identified.

To determine the patient's thermal threshold, we use a single spot and we start to use a low power that we increase gradually until a just-visible burn endpoint (barely visible threshold burn) is observed in a normal flat area of retina outside the edema.

We wanted to test these parameters on an area outside the edematous one but close to it (in other words, in the "flat" area that is considered healthy/normal).

At our facility in Oxford, UK, the majority of our patients are Caucasian. With this patient, we usually obtain a visible reaction somewhere between 1000 mW and 1400 mW.

Once the thermal threshold is determined for any one given retina, we reduce the power to 50% of this threshold power for MicroPulse treatment (ie, from 500 mW to 700 mW).

In cases of diabetic macular edema, we treat the entire area of edema using an optical coherence tomography-guided treatment protocol.

For central serous chorioretinopathy, we treat the hyperfluorescent areas on mid-phase indocyanine green angiography (ICGA) and the "hot spots" on mid-phase fluorescein angiography (FA), using an ICGA/FA-guided treatment protocol.

Go to www.retina-yellow-laser-therapy.com to view these guidelines and a video of Dr. Chong. ■

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