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Elegantly Simple Solutions™

Why 577 nm Yellow?

Clinical Benefits of 577 nm Yellow Laser in the Treatment of Ocular Disorders

IQ 577™ Laser Benefits

Overview of Ocular Photocoagulation Lasers with Yellow Wavelengths

Understanding Laser-Tissue Interaction, Absorption, and Conversion of Laser Energy into Heat

MicroPulse™ Technology for Tissue-Sparing Photocoagulation

Laser Treatment Strategies

IQ 577™ Laser Benefits

1. High transmission through dense ocular media[1, 2]
   - Longer wavelength with lower light scattering results in less power needed for the intended retinal irradiance
2. Consistent laser lesions for fast procedure time (See Figure 3)
   - Consistent tissue uptake and reduced thermal spread
   - Less frequent need to readjust laser parameters
3. Enhanced visibility for reduced intraretinal damage[2]
   - Enables early observation of very light tissue reactions at the level of the retinal pigment epithelium (RPE)
4. Low power required for increased patient comfort[3]
   - Lower transmission to deeper tissues[2,4]
5. Allows treatment closer to the macula
   - Negligible absorption by xanthophyll[2]
6. Most efficient focal treatment of vascular structures (See Figure 1)
7. Tissue-sparing capability through MicroPulse™ technology

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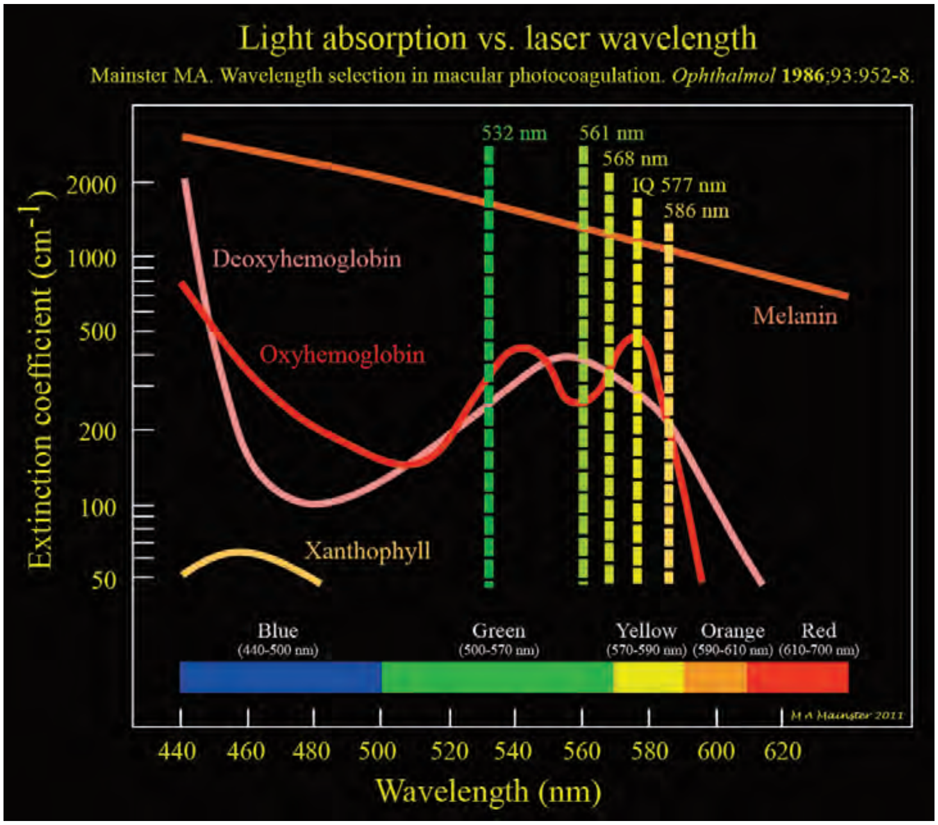
Figure 1. Laser Wavelength & Effective Light Absorption



Laser	λ (nm)	HbO	HbR	Melanin	Ratio HbO/HbR	Ratio HbO/Melanin
		— Extinction Coefficient cm-1 —				
Argon Green	514	150	160	1850	0.94	0.08
FD Nd:YAG Green	532	320	250	1600	1.28	0.20
DPSS “Yellow”	561	250	375	1300	0.67	0.19
Krypton “Yellow”	568	330	330	1200	1.00	0.28
IRIDEX Yellow	577	460*	275	1130	1.67	0.41^
FD Nd:GdVO4 Yellow	586	210	210	1040	1.00	0.20

* 577 nm is at the absorption peak of HbO, which is important for direct treatment of vascular structures.[2]

^ 577 nm has the highest ratio of HbO to melanin extinction to minimize damage to underlying pigmented tissue.[2]

Overview of Ocular Photocoagulation Lasers with Yellow Wavelengths

Argon-dye laser photocoagulators were introduced in the mid-1980s and quickly became popular with retina specialists. Using argon-dye photocoagulators, clinicians could select green (514 nm), and a tunable range of wavelengths providing greenish-yellow to orange to red (560 nm to 630 nm); among them, the 577 nm (yellow) - at the peak of the oxyhemoglobin absorption curve - quickly became the favorite wavelength for a variety of reasons including less scatter and increased efficiency. Eventually, argon-dye photocoagulators became less popular because they were costly, complex, and difficult to maintain.

The next yellow laser wavelengths became available in a 3-color krypton laser that delivers 568 nm, followed by solid-state lasers that deliver 561 nm, 568 nm, 577 nm, and 586 nm – all marketed as "yellow" light; however, not all yellow wavelengths are alike: 561 nm and 568 nm are in the *green* wavelength spectrum (500 nm to 570 nm). Although both 577 nm and 586 nm are in the yellow wavelength spectrum (570 nm to 590 nm), 577 nm has higher absorption coefficients in oxyhemoglobin (HbO), deoxyhemoglobin (HbR), and melanin. (See Page 3)

The importance of laser wavelength absorption characteristics is discussed below.

Understanding Laser-Tissue Interaction, Absorption, and Conversion of Laser Energy into Heat

1. There are three principal chorioretinal light-absorbing chromophores:

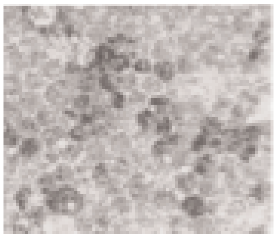
   Melanin

   Melanin is the most effective light-absorbing chromophore. It's located in the RPE and choroid, where light energy converts into heat. Light absorption in melanin decreases with increasing wavelengths. Melanin concentration varies among patients and fundus locations, producing variability in light absorption. (See Figure 2)

   Hemoglobin

   HbO and HbR are important absorbers after melanin. Their absorption spectrum (See Figure 1) is characterized by distinctive peaks: 542 nm green and 577 nm yellow in HbO; and 555 nm in HbR. High choriocapillaris hemoglobin absorption provides more uniform laser effects in patients with light or irregular fundus pigmentation. (See Figure 3)

Figure 2.
Variability of Melanin Distribution



Human RPE shows irregular distribution of melanin.
Geeraets WJ, et al.
The relative absorption of thermal energy in retina and choroid.
Invest Ophthalmol 1962;1:340-7

   Xanthophyll

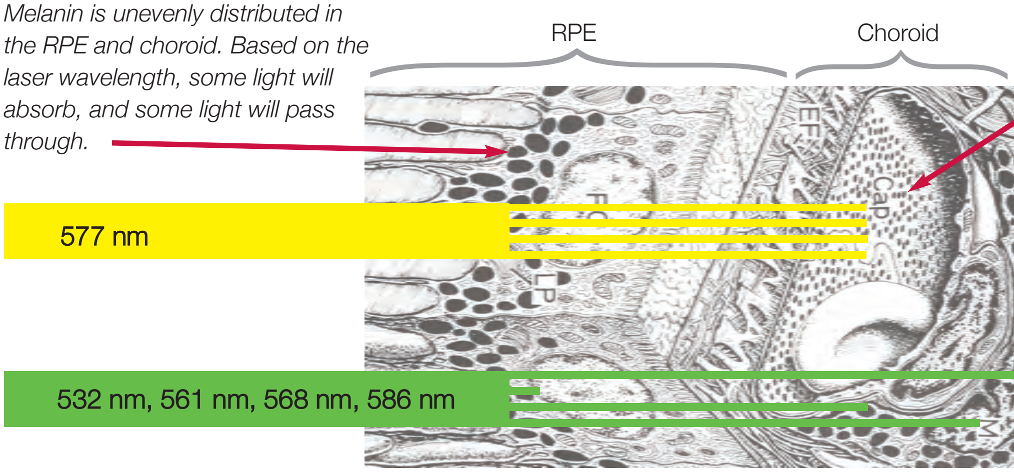
   Xanthophyll is located in the inner and outer plexiform layer of the macula where thermal damage is undesirable. 577 nm is minimally absorbed by xanthophyll, so there is negligible light absorption in the inner retina or its resultant temperature elevation.

2. Laser energy is absorbed in the RPE from which heat can spread to the overlying neurosensory retina. When the retina becomes thermally damaged it loses its transparency and scatters white slitlamp light back at the observer which appears as a "blanching" endpoint. Higher temperature results in greater loss of retinal transparency with increased scattering and whiter endpoint. (See Figure 4)

Figure 3. Melanin and HbO Absorbing Chromophores Increase Efficiency of 577 nm

577 nm has the highest combined absorption in the melanin-oxyhemoglobin layers of the RPE/choriocapillaris complex. (See Figure 1)

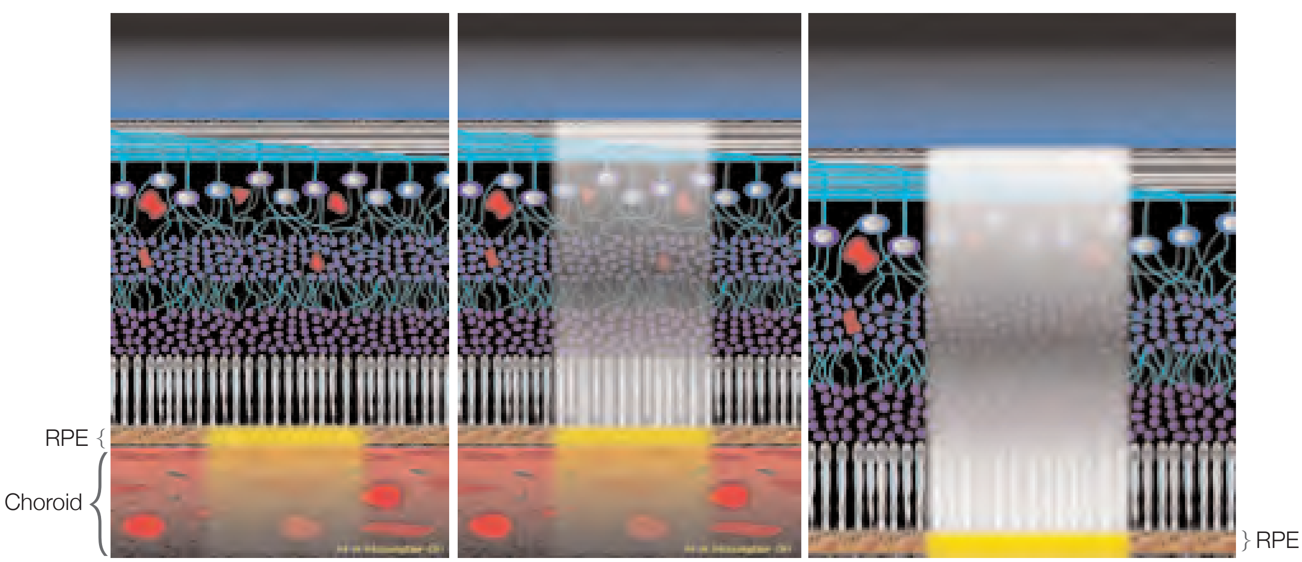
Melanin is unevenly distributed in the RPE and choroid. Based on the laser wavelength, some light will absorb, and some light will pass through.



Hemoglobin in the choriocapillaris is more uniformly distributed for a more consistent uptake of laser light. 577 nm has the highest absorption coefficient in HbO. (See Figure 1)

The lower absorption and increased transmission of 577 nm through the non-uniform melanin granules of the RPE is more than compensated by the higher absorption of 577 nm in the underlying more uniformly distributed hemoglobin-rich choriocapillaris.

Figure 4. Conversion of Light Energy into Heat



Heat conduction spreads temperature rise from laser light-absorbing pigmented tissues (melanin in the RPE and choroid, and hemoglobin in the chorio-capillaris in the choroid) to overlying neurosensory or collateral retina.

The overlying retina damaged by heat conduction loses its transparency and scatters white slit-lamp light back at observers.

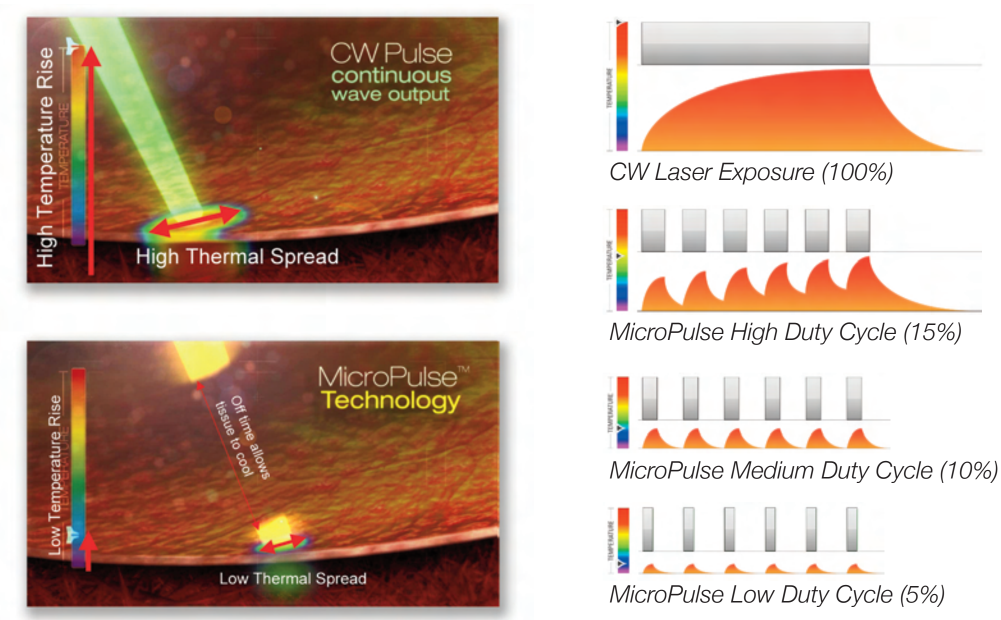
More damage means less transparency and a whiter lesion.

Illustrations compliments of Martin A. Mainster, PhD., MD, FRCOphth

MicroPulse™ Technology for Tissue-Sparing Photocoagulation

MicroPulse is a tissue-sparing laser technology and dosing protocol that can limit thermal elevation to temperatures below the threshold of retinal tissue damage to induce beneficial intracellular biological effects without any visible laser–induced damage during and at any time post treatment. (See Figure 5) Early MicroPulse protocols used 810 nm, and have been refined over the years to further improve treatment outcomes while continuing to do no harm. More recently, studies using 577 nm MicroPulse protocols have been presented.

Figure 5. MicroPulse Technoloy



In conventional, continuous-wave (CW) photocoagulation, a rapid temperature rise in the target tissue creates blanching and a high thermal spread. MicroPulse technology finely controls thermal elevation by "chopping" a CW beam into a train of repetitive short pulses allowing tissue to cool between pulses and reduce thermal buildup.

The clinical efficacy of MicroPulse protocols has shown favorable therapeutic responses with minimized collateral effects in the treatment of diabetic macular edema (DME),[5-19] proliferative diabetic retinopathy,[6, 20, 21] macular edema secondary to branch retinal vein occlusion (BRVO),[6, 22-24] and central serous chorioretinopathy (CSC).[25-30]

In a prospective, randomized, controlled clinical trial for DME, MicroPulse photocoagulation has demonstrated to be as effective as conventional (Early Treatment of Diabetic Retinopathy Study) photocoagulation in **stabilizing visual acuity and in reducing macular edema, with the benefits of no tissue damage detectable at any time point postoperatively and of significant improvement in retinal sensitivity.**[15]

In 2010, the first study was reported on the use of the IQ 577™ in its MicroPulse mode to treat CSC. Results showed all patients had complete resolution of their symptoms, there was functional visual improvement, and there were no signs of laser marks on the treated areas by clinical examination or fluorescein angiography.[31] Additional studies using 577 nm tissue-sparing photocoagulation have shown clinical effectiveness for the treatment of CSC,[32] DME,[33, 34] and BRVO.[35] (See Figure 6)

Laser Treatment Strategies

577 nm Continuous-Wave Mode

The 577 nm wavelength photocoagulator has been shown to produce visible endpoints similar in both appearance and clinical efficacy to those achieved using green laser photocoagulators, while requiring only 60% to 70% of the green laser power.[1, 3] Therefore, a useful way to familiarize yourself with the ophthalmic response to 577 nm wavelength strategy might be to initiate each laser treatment with 50% to 60% of the power you would normally use with your green laser; keep all other techniques and parameters the same. Titrate power to achieve your desired endpoint. Note that focal treatment of microaneurysms may be accomplished using very low powers (90 to 130 mW) compared to other visible wavelengths.[36] Anecdotal experience has shown powers as low as 50 mW.

Note: The IQ 577™ laser has a user preference selection to automatically turn off the aiming beam during treatment laser emission. This allows you to more easily observe the earliest and most subtle visible tissue reactions at the level of the RPE without the distraction and contrast reduction due to scattered aiming beam light.

MicroPulse™ Mode

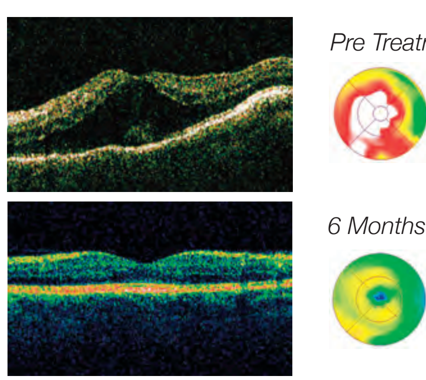
MicroPulse is typically used to administer subvisible threshold laser treatments to macular and perimacular targets. When used here, the terms “subvisible,” “subvisible threshold,” or “subthreshold” denote that the desired endpoint is one in which treated tissue offers no ophthalmoscopically observable laser effects. Nevertheless, 577 nm and 810 nm studies have confirmed that subvisible laser treatment strategies can be clinically effective while inducing no tissue changes discernable by slitlamp observation, fluorescein angiography (FA), or fundus autofluorescence (FAF) at any time post-operatively.[15, 35] Subvisible MicroPulse laser treatments are consistently effective without causing such changes because the total laser energy is only a percentage (often chosen by clinicians to be 20-70%) of that needed to produce a visible endpoint.

Energy (J) is equal to [Laser Power (W)] x [Exposure Duration (s)] x [Duty Factor (%/100)]. Duty Factor is often 5% to 15% when using MicroPulse mode, and is 100% when using CW mode. Clinicians have reported various strategies to adjust these parameters relative to suprathreshold burns in order to achieve clinically effective subvisible endpoints.[13, 15, 19, 35]

Additional parameters to consider in any laser treatment protocol, and particularly during MicroPulse, is spacing between laser treatment spots, and the total number of treatment spots administered. Due to the limited thermal spread of MicroPulse exposures, subvisible treatments often call for the administration of a greater number of treatment spots with denser spacing than used for threshold laser grid treatments.[17]

For more information on MicroPulse, register at www.iridex.com/micropulse

Figure 6. IQ 577 MicroPulse Treatment of Macular Edema Secondary to BRVO



Pre Treatment: 20/100

6 Months Post Treatment: 20/20

Images compliments of Stanislav Saksonov, MD; and Sviatoslav Suk, MD, PhD Eye Microsurgery Center, Laser Unit, Kiev, Ukraine

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