ALT, MLT, SLT

What does it matter?

BY ROBERT J. NOECKER, MD, MBA

Laser trabeculoplasty has played a significant role in the treatment of open-angle glaucoma for the past several decades. The procedure was originally performed with the argon laser, but several other wavelengths have now been used and shown to be effective for this application. Recently, different technologies have been developed in an attempt to maintain laser trabeculoplasty's efficacy while minimizing its side effects. This article compares argon laser trabeculoplasty (ALT), selective laser trabeculoplasty (SLT), and multipulse laser trabeculoplasty (MLT).

WAVELENGTH

To determine the relative impact of any new laser technology on biologic tissue, it is worthwhile to review the laser/tissue interactions that occur. With laser trabeculoplasty of all types, the chromophore or target is melanin, which absorbs visible light very well—especially the green light with a wavelength of 532 nm used in SLT. Argon lasers emit light in the green and blue-green range, which is also well absorbed by melanin. In recent years, double-frequency Nd:YAG lasers have slowly replaced traditional argon lasers for ALT, but the principles of the procedure are the same. These solid-state lasers are generally more portable and less expensive to operate than traditional gas lasers. MLT uses a longer wavelength of 810 nm, which is generated by a diode laser. Because this wavelength is not as efficiently absorbed by melanin as the shorter visible wavelengths of light, it typically penetrates tissue more deeply.

SPOT SIZE AND ENERGY

The spot size is 50 µm in ALT, 400 µm in SLT, and 300 µm in MLT. The difference in spot size influences how much irradiance or energy per square area is applied to the trabecular meshwork. SLT generally uses energies of approximately 0.6 to 1.2 mJ per pulse compared with 40 to 70 mJ per pulse for ALT and 0.6 mJ per pulse for MLT.

DURATION OF TREATMENT

The greatest difference between ALT, SLT, and MLT is the amount of time that laser energy is applied to the trabecular meshwork. In ALT, the pulse duration is usually 0.1 seconds versus 3 nanoseconds in SLT. For MLT, the typical pulse duration is 0.2 seconds divided into 100-microsecond pulses at a duty cycle of 15%. The pulse duration has a significant impact on the type of laser/tissue interaction that occurs with each application of laser energy.

For exposure to laser energy in the range of that used in ALT, melanin absorbs the light energy and converts it into heat, which in turn creates thermal damage with subsequent coagulative necrosis. The amount of damage is not limited to the treatment area but extends beyond the trabecular cells that contain melanin. The trabecular beams and other extracellular tissues sustain significant damage.

In SLT, the pulse duration is shorter than the thermal relaxation time of biologic tissue. Although the melanin granules within trabecular cells absorb the laser energy, there is no heating of adjacent tissues. As a result, the damage to the pigment-containing trabecular cells is limited, and the trabecular beams sustain no permanent structural damage, as occurs during ALT.

MLT uses a train of low-irradiance 300-microsecond laser pulses that theoretically thermally affect but do not destroy pigmented cells in the trabecular meshwork. Cycling the application of the laser energy on and off minimizes the rise in temperature in the treated tissue. That way, the tissue is able to "cool off" while the energy application is "off." In theory, MLT generates enough thermal energy to injure but not destroy cells.

MECHANISM OF ACTION

Regardless of the physics of each laser used for trabeculoplasty, a common pathway of events appears to occur to reduce the IOP. The pressure seems to decrease not due to a drilling of drainage channels or contraction of tissue, but rather due to an increase in the meshwork's permeability and the resultant rise in outflow. After laser trabeculoplasty, there appears to be an immediate release of cytokines followed by monocytic recruitment that facilitate greater permeability.[1,2]

Based on this information, the damage to tissue that occurs during ALT and trabeculoplasty with other lasers using longer pulse durations appears to constitute an unnecessary overtreatment. That is, the damage that occurs to structures such as the trabecular beams does not seem necessary to generating the common pathway response of cytokine release and monocytic activation and recruitment. The clinically observable IOP-lowering effect is comparable among the various techniques of laser trabeculoplasty in the short term, whether or not that technique causes structural damage.

EFFICACY

The Glaucoma Laser Treatment Trial established the efficacy of laser trabeculoplasty. This prospective study compared the use of ALT and medical therapy for the treatment of glaucoma. Two hundred seventy-one patients with previously untreated primary open-angle glaucoma were randomized to ALT or medication. Through a 2-year follow-up period, the eyes treated with ALT had a lower mean IOP than those treated with medication, and 25% of those ALT-treated eyes did not require medical treatment. At 7 years, in 203 of the original 271 patients, ALT-treated eyes had on average a lower IOP, better visual fields, and a better optic disc status than eyes in the medication group.[3] The Glaucoma Laser Treatment Trial had limitations such as randomization by eye rather than individual, an antiquated medical treatment regimen, a small sample size, a heterogeneous early glaucoma population, and the fact that most of the patients treated with ALT ended up requiring medications.

SLT was developed in the 1990s as an alternative to ALT and traditional laser trabeculoplasty. SLT seems to lower IOP comparably to ALT without coagulative damage.[4] In the past decade, numerous articles have demonstrated the efficacy and safety of SLT. One of the first studies by Latina et al showed that SLT was efficacious in patients on maximally tolerated medical therapy in whom prior laser trabeculoplasty had failed.[5] Subsequent studies have shown SLT to be efficacious in previously untreated patients as well.[6] Damji et al showed similar levels of IOP lowering between SLT and ALT over 1 year.[7]

A more recently introduced technology, MLT uses a different strategy than SLT to reduce the amount of energy that is delivered to the trabecular meshwork. Clinically, there is less information available about MLT than either SLT or ALT. Small short-term studies[8] and anecdotal reports show that MLT lowers IOP comparably to the other competing techniques. Yet to be confirmed are the theoretical advantages of a lesser thermal effect than ALT that MLT promises.

CONCLUSION

The decrease in IOP that laser trabeculoplasty can achieve seems to be similar with all of the available technologies. The differentiating factors between ALT, SLT, and MLT are the collateral damage and the incidence of side effects with each technique. Clinically, the most common side effects observed with laser trabeculoplasty are IOP spikes and anterior segment inflammation. The latter tends to be lesser with SLT, and anti-inflammatory medications are not used after this procedure. The one complication that has been reported with ALT but not SLT or MLT is the formation of peripheral anterior synechiae. This difference speaks to the thermal nature of ALT compared with SLT and perhaps MLT. ALT also tends to be more uncomfortable to the average patient than SLT during the treatment.[5]

It seems that any thermal effects that extend beyond the cellular level are undesirable and can lead to decreased clinical safety in the form of IOP spikes, the formation of peripheral anterior synechiae, and inflammation. The incidence of IOP spikes varies significantly due to differences in the populations and treatment parameters, but the rate of this complication appears to be lower with SLT than ALT. Although the use of preoperative medications to decrease the incidence of IOP spikes is effective with any type of trabeculoplasty, the rate of untreated IOP spikes tends to be lower with SLT and MLT compared with ALT. Studies have reported a 30% incidence of elevations in IOP greater than 5 mm Hg with ALT, an incidence of less than 10% with SLT, and only one eye in the MLT study.[8-10]

As ophthalmologists continue to use laser trabeculoplasty earlier in the treatment algorithm for glaucoma, these factors may become increasingly important. ❑

Robert J. Noecker, MD, MBA, is the director of the Glaucoma Service and an associate professor/ vice chair at the Department of Ophthalmology at the University of Pittsburgh. He has received research funds from Iridex Corporation and Lumenis Inc. within the past 2 years. Dr. Noecker may be reached at (412) 647-5753; noeckerrj@upmc.edu.

1. Samples J. Effect of wavelengths on trabecular cell division after laser trabeculoplasty [Abstract 1673]. *Invest Ophthal Vis Sci.* 1990;31(4).
2. Alvarado JA, Alvarado RG, Yeh RF, et al. A new insight into the cellular regulation of aqueous outflow: how trabecular meshwork endothelial cells drive a mechanism that regulates the permeability of Schlemm's canal endothelial cells. *Br J Ophthalmol.* 2005;89(11):1500-1505.
3. Glaucoma Laser Trial Research Group. The Glaucoma Laser Trial (GLT) and Glaucoma Laser Trial Follow-up Study: 7. Results. *Am J Ophthalmol.* 1995;120(6):718-731.
4. Kramer TR, Noecker RJ. Comparison of the morphologic changes after selective laser trabeculoplasty and argon laser trabeculoplasty in human eye bank eyes. *Ophthalmology.* 2001;108(4):773-779.
5. Latina MA, Sibavan SA, Shin DH, et al. Q-switched 532-nm Nd:YAG laser trabeculoplasty (selective laser trabeculoplasty): a multicenter, pilot, clinical study. *Ophthalmology.* 1998;105(11):2082-2088; discussion 2089-2090.
6. Melamed S, Ben Simon GJ, Levkovitch-Verbin H. Selective laser trabeculoplasty as primary treatment for open-angle glaucoma: a prospective, nonrandomized pilot study. *Arch Ophthalmol.* 2003;121(7):957-960.
7. Damji KF, Bovell AM, Hodge WG, et al. Selective laser trabeculoplasty versus argon laser trabeculoplasty: results from a 1-year randomised clinical trial. *Br J Ophthalmol.* 2006;90:1490-1494.
8. Detry-Morel M, Muschart F, Pourjavan S. Micropulse diode laser (810 nm) versus argon laser trabeculoplasty in the treatment of open-angle glaucoma: comparative short-term safety and efficacy profile. *Bull Soc Belge Ophthalmol.* 2008;308:21-28.
9. Lanzetta P, Menchini U, Virgili G. Immediate intraocular pressure response to selective laser trabeculoplasty. *Br J Ophthalmol.* 1999;83(1):29-32.
10. Ma YR, Lee BH, Yang KJ, Park YG. The efficacy of .02% brimonidine for preventing intraocular pressure rise following argon laser trabeculoplasty. *Korean J Ophthalmol.* 1999;13(2):78-84.

LT0468