How SLT Works

A technological hybrid for selective laser trabeculoplasty effectively treats glaucoma without damaging the trabecular meshwork.

BY ROBERT J. NOECKER, MD, MBA

Mark Latina, MD, of Reading, Massachusetts, developed selective laser trabeculoplasty (SLT) to achieve the benefits of argon laser trabeculoplasty (ALT) while causing fewer side effects. Whereas SLT does not significantly heat ocular tissue, ALT causes irreversible coagulative necrosis to the treated trabecular meshwork. If initial treatment of 180° ALT does not effectively lower the IOP, the surgeon should usually augment the procedure in the opposite 180° only, and total treatment is usually limited to 360°. With ALT, peripheral anterior synechiae often form postoperatively, which can increase IOP in the long term. Conversely, because SLT treats only pigmented cells, it does not cause structural damage to the trabecular meshwork, which can then be repopulated by endothelial cells. Theoretically, the number of treatments is not limited by structural damage, and therefore SLT is much safer and more repeatable than ALT. This article focuses on the mechanism and utility of SLT.

THE LASER

The Selecta II Glaucoma Laser System (Lumenis Inc., Santa Clara, CA) is a technological hybrid consisting of a double-frequency Nd:YAG laser, which works at a green wavelength (532 nm). Melanin absorbs this green light just as it does argon and other visible wavelengths of light. Rather than burn tissue to achieve the desired effect, the Selecta Duet laser (Lumenis Inc.) does not significantly heat the trabecular meshwork due to its brief pulses of energy (3 nanoseconds). The traditional Nd:YAG laser is ineffective for laser trabeculoplasty because its wavelength is not absorbed by pigment-containing structures. The exposure times of typical continuous-wave lasers are too long and cause thermal damage to ocular tissue. In ALT, the pulses of laser energy last longer than in SLT and cause burns that result in ongoing coagulative damage, sometimes for years.

The Selecta Duet laser’s spot size is 400 µm in diameter, much larger than the typical spot size (10 µm) of an Nd:YAG laser focused on the posterior capsule or the iris. The larger spot size is less harmful to ocular tissue because the energy is not concentrated in a small area. The low fluency of energy safely and effectively diffuses over a larger area. Because the relative amount of energy placed in the eye per pulse per given area is at least 10,000 times lower with SLT than ALT, the treatment achieves the desired effect without focal damage.

MECHANISM OF ACTION

In a process known as selective photothermolysis, SLT targets only pigmented trabecular cells and causes no structural or coagulative damage to the trabecular meshwork. For selective photothermolysis to occur, there must be a targeted intracellular chromophore (melanin) and no competing chromophores (such as blood) present. In other words, there must be pigment in a cell for it to be a target that will absorb the laser energy better than surrounding tissues. The laser’s brief pulse duration confines heat to the pigmented cells within the irradiated zone. For example, during SLT, the laser targets pigmented cells and does not damage the nonpigmented trabecular cells or collagen beams. In contrast, ALT destroys all cells (with and without pigment) in a culture model.1

ALT destroys a viable area of the trabecular meshwork, creates a crater in this tissue, and causes a
depopulation of all the normal structures. A region treated with SLT, however, has a normal appearance and can be repopulated by trabecular cells (Figure 1).

LOWERING THE IOP

SLT has numerous biological effects. For example, it causes a proliferation of trabecular and endothelial cells, the release of cytokines, inflammation (recruitment of macrophages), and phagocytosis. The ultimate result is increased aqueous outflow.2

Clinically, several distinct phases in the photoactivation process occur after SLT. First, the laser targets and destroys cells containing melanin. Treatment generates small bubbles, which may float into the anterior chamber. These “champagne” bubbles signal to me that I am near the energy threshold of treatment effect. Hours or days after SLT, an intermediate cellular response is noticeable. Biologically, the activity of the trabecular meshwork’s cells and macrophages increases. Nuclear translocation of transcription factors and an induction of vasoactive agents (eg, a release of cytokines) occur, and the recruitment of macrophages begins. The IOP decreases as the repair process begins.

In the long term (months or years), the number of macrophages present in the trabecular meshwork increases and thus improves the eye’s outflow facility.3 Cytokines play many roles. They act as growth factors for human trabecular meshwork cells, which repopulate the treated areas. These cells can act at the level of Schlemm’s canal to increase transendothelial fluid flow. They are also involved in the expression of certain metalloproteinases and stimulate the remodeling of the extracellular matrix of the trabecular meshwork’s tissues. The latter action promotes aqueous outflow.

It is not uncommon for the IOP to drop precipitously the day after SLT. A slight increase in pressure may occur during the intermediate phase when cellular infiltration begins. For instance, a patient may have a higher IOP 10 to 14 days after SLT. In the long term, IOP tends to level out, and the IOP gradually drops as the remodeling process continues (Figure 2). Clinicians may wish to observe patients whose initial postoperative IOPs are not sufficiently low, because SLT’s maximal effect may not occur for several months.

FIRST-LINE TREATMENT

Whereas surgeons typically perform ALT after medical therapy has failed and prior to surgical intervention, SLT may be appropriate as primary therapy for some patients with open-angle glaucoma. The 13-site SLT/MED study will compare SLT with stepped medications as the initial monotherapy for the treatment of glaucoma. Three hundred patients have been randomized to receive either medication or SLT as initial intervention. My co-investigators and I will follow these individuals for 12 months to see which treatment arm is more effective in terms of slowing glaucomatous progression.

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