

Current Concepts in Laser Trabeculoplasty

Advances in technology make this option an attractive alternative or adjunct to medical therapy.

BY JASON BACHARACH, MD

Key innovations in the evolution of laser trabeculoplasty (LTP) have made it a safe and effective option for glaucoma management. Krasnov first reported applying multiple burns to the trabecular meshwork with a ruby laser more than 40 years ago.¹ Wise and Witter's pilot study in 1979 demonstrated the argon laser's efficacy at lowering IOP.² Almost 25 years ago, the Glaucoma Laser Trial (GLT) showed that primary LTP effectively lowers IOP in treatment-naïve eyes; at year 2, LTP controlled IOP more effectively than timolol alone (44% vs 30%).³ Concerns included a loss of efficacy over time as well as the formation of peripheral anterior synechiae after laser treatment. Latina and Park pioneered the use of the frequency-doubled Nd:YAG laser to selectively target the pigmented epithelium (selective laser trabeculoplasty [SLT]). This innovation addressed the aforementioned concerns, as histologic evaluations have shown minimal structural damage to the trabecular meshwork.^{4,5}

Today, physicians have access to various laser systems that have a better side effect and lower risk profile than earlier iterations of the technology. Recent studies have identified new concepts regarding the mechanism of action, repeatability, and diurnal effect. Additional research has focused on the relationship between lasers and medication, including comparisons of their efficacy and cost, their roles in the treatment of glaucoma, and which medications are most efficacious when used in combination with LTP.

CONTEMPORARY LASER OPTIONS

Selective Laser Trabeculoplasty

SLT uses several thousand times less energy than argon laser trabeculoplasty (ALT) to selectively target the pigmented trabecular meshwork cells. The benefits of SLT have been demonstrated histologically by means of electron microscopy.⁵ Studies have verified SLT's effectiveness, including research demonstrating an IOP reduction that is at least comparable to that achieved through medical therapy with latanoprost.^{6,7} A recent multicenter study (SLT/Med Study) compared SLT with a stepped regimen of medications. The investigators found that the IOP was similar in both arms after 1 year, although more treatment steps were necessary to maintain the target IOP in the medication group.⁸

Micropulse-Diode Laser Trabeculoplasty

This technology is evolving. Recent adjustments include using a wavelength of 532 nm rather than 810 nm. The spot size for micropulse-diode laser trabeculoplasty (mDLT) is slightly smaller than for SLT (300 μ m vs 400 μ m). The uniqueness of the mDLT system is that it breaks continuous-wave laser energy into small, repetitive micropulses, allowing energy to be delivered with intermittent cooling periods (Figure). This cooling period reduces thermal buildup and subsequent tissue damage while retaining LTP's biological effects.⁹ The technology is promising, and surgeons have anecdotally reported excellent results.¹⁰

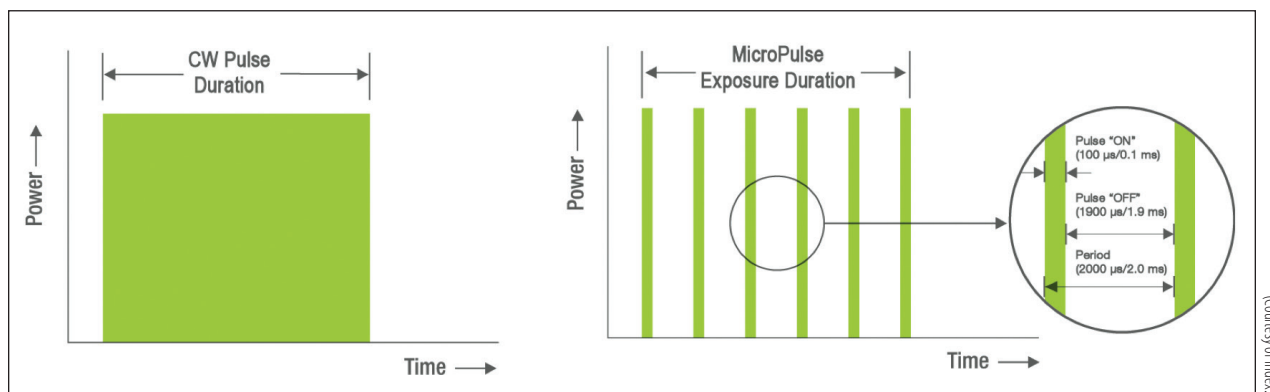


Figure. Micropulse-diode laser trabeculoplasty breaks continuous-wave laser energy into small, repetitive micropulses, which allows energy to be delivered with intermittent cooling periods.

Titanium-Sapphire LTP

Titanium-sapphire LTP uses a longer wavelength (790 nm) than either SLT or current mDLT technologies. This near-infrared wavelength may allow deeper penetration to the juxtacanalicular meshwork. Although commercialization of the titanium-sapphire LTP system is limited, it has demonstrated similar efficacy as ALT based on this author's experience.¹¹

MECHANISM OF ACTION

Overview

Although the exact mechanism by which LTP works remains elusive, there are multiple theories that are not necessarily mutually exclusive. In addition, the newer modalities likely rely less on the mechanical theory than ALT. The mechanical, biologic, and repopulation theories all involve an improvement in trabecular flow, whereas the uveoscleral theory describes an ancillary to trabecular outflow.

Mechanical Theory

According to the mechanical theory, electromagnetic energy is converted to heat energy. When laser energy is applied to the trabecular meshwork, a contraction burn causes stretching of the adjacent portions of tissue. This stretching reduces resistance to flow in the trabecular meshwork and Schlemm canal, thereby improving conventional outflow.¹²

Biologic Theory

Thermal energy through cytokine mediators stimulates macrophage recruitment, which causes remodeling and "cleaning" of the obstructed meshwork. Multiple chemotactic and vasoactive agents are upregulated, including interleukin-1 and tumor necrosis factor. These agents upregulate metalloproteinase expression, which in turn

triggers a remodeling of the meshwork, thus increasing outflow. This is the favored theory for the newer lasers, because very little mechanical damage is induced with their application.^{4,13}

Repopulation Theory

Laser energy stimulates an increase in cell division and trabecular meshwork repopulation.¹⁴

Uveoscleral Theory

Recent research suggests that SLT improves uveoscleral outflow in addition to trabecular outflow.¹⁵ Uveoscleral theory is consistent with the belief that SLT functions in a fashion that is very similar to a prostaglandin drop.¹⁶

REPEATABILITY

A major concern with repeat ALT was its lack of efficacy and the increased risk of IOP spikes with greater than 360° of treatment.¹⁷ There is evidence that repeat treatment with SLT has more positive results with less risk.¹⁸ This author's positive experience with repeat SLT was included in a multicenter collaboration presented at the American Glaucoma Society's annual meeting and corroborated others' experiences.¹⁹

DIURNAL EFFECTIVENESS

Studies conducted at sleep laboratories have shown SLT to be effective at limiting IOP fluctuations, which might help to reduce disease progression.²⁰

COMPLEMENTARY PHARMACOTHERAPY

If SLT works similarly to a prostaglandin, mechanistically, it would make sense that classes of medication other than prostaglandin analogues would be more synergistic with SLT for lowering IOP. Experience

(Courtesy of iStock)

suggests that aqueous suppressants are an excellent adjunct when the IOP target is lower than achieved with SLT alone.²¹

CONCLUSION

This era of cost-conscious care is prompting a resurgence in interest in LTP. Newer laser modalities may provide a safe and effective way to diurnally control IOP, thereby reducing concerns related to patients' adherence to pharmacotherapy. ■

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