Laser Trabeculoplasty Versus Filtering Surgery

These approaches respectively aim to lower IOP by means of laser treatment directed at the trabecular meshwork and by reshaping the filtration pathway.

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Laser trabeculoplasty is a modern intraocular pressure (IOP)-lowering procedure that aims to reduce IOP by means of laser treatment directed at the trabecular meshwork. The goal of laser trabeculoplasty is to prevent uncontrolled IOP from damaging the optic nerve. Unlike penetrating or nonpenetrating filtering surgeries, laser trabeculoplasty does not require direct access to the trabeculum or Schlemm canal. This can be considered an advantage for patients who are unwilling or unable to undergo a procedure in the operating room.

LASER TRABECULOPLASTY

Indications. The following are indications for laser trabeculoplasty: (1) the patient has insufficient response to medical IOP-lowering therapy, meaning the target pressure cannot be reached or, depending on optic nerve damage and visual field defects, the target pressure must be lowered; (2) the patient is intolerant to antiglaucoma medications, for example because of cardiorespiratory side effects such as bradycardia, asthma, and respiratory distress or ocular surface problems such as dry eye syndrome, itching, and red eye; and (3) laser treatment is performed to supplement medical therapy in order to postpone filtration surgery.

The trabecular meshwork, particularly the juxtacanalicular meshwork, is the chief locus of resistance to the egress of aqueous humor. Filtration is reduced due to a decrease in water conductance in the meshwork. The reasons for this are numerous and could be related to inability of trabecular cells to metabolize debris floating in the anterior chamber (ghost cells, iris pigment, and inflammation cells).

The trabeculum does not form a dense and impermeable wall to the transport of material but rather a 3-D network of fibrils with large openings in the mesh. Contraction of the fibers interlaced in the trabecular meshwork bundles leads to changes in the geometry of this grid. The direct consequence of these changes is a dramatic modification in the water conductance and, conversely, the resistance to aqueous humor outflow through the trabeculum. Alteration of this reduced outflow was reported several decades ago, after administration of pilocarpine. Shortening of the ciliary muscles by this miotic agent results in stretching of the trabecular meshwork, likely resulting in a widening of the mesh and lowering of IOP.

Lasers were first used in eye surgery in the late 1960s, and, initially, the argon laser was employed for argon laser trabeculoplasty (ALT). An argon laser typically emits energy at a wavelength of 514 nm, and its effects on tissues are numerous, depending on the energy and area of the target surface. Thermal energy is dissipated around the spot when the beam reaches the tissue, and energy is absorbed by the pigmented trabecular meshwork. The effects of energy absorption vary with the duration, extent of impact, and degree of pigmentation of the targeted tissues.

Mild energy results in alterations in cellular metabolism, eventually leading to cell...
death. Moderate energy leads to molecular configuration changes and protein coagulation (eg, collagen bundles), resulting in tissue shrinkage, which is the desired effect of ALT. High energy causes destruction of tissues and resultant scarring.

In ALT, direct laser application at the surface of the trabecular meshwork is used to alter cell geometry, and as a result of localized shrinkage of collagen of the uveal and corneoscleral trabecular lamellae, to enlarge the mesh and improve outflow facility.8 Laser burns also act as a chemoattractor to stimulate macrophages and phagocytes to clean up debris and cell remnants within the trabecular meshwork to further enhance aqueous outflow. Cell turnover is stimulated, resulting in generation of new, more functional trabecular cells with better outflow properties.8

More recently, nonthermal laser energy has been used to change the cell geometry. Selective laser trabeculoplasty (SLT), using a 532-nm, frequency-doubled, q-switched Nd:YAG laser, was developed to selectively target the pigmented trabecular meshwork cells without causing thermal or collateral damage to the nonpigmented cells or structures of the trabecular meshwork.9

SLT is now a widely used procedure for lowering IOP. The principle of this procedure lies in targeting trabecular cells that are disrupted, thus creating a continuity in the trabecular meshwork and reducing the resistance to aqueous egress.

Surgical approach. To perform laser trabeculoplasty, the iridocorneal angle should be clearly visible (Figure 1). Any corneal opacity or clouding that might impair proper visualization of the angle structure is a contraindication. Similarly, peripheral anterior synchiae or large iris processes will impede access to the anterior trabeculum and limit the extension of laser treatment (Figure 2). A closed or very narrow iridocorneal angle is a contraindication for laser trabeculoplasty.

In preparation, the pupil should not be dilated, allowing a good view of the angle. Miotics can be given to ensure proper visualization. An alpha-2-adrenergic agent such as apraclonidine 1% can be administered preoperatively to minimize postoperative IOP rise.

After topical anesthesia, a gonioscope is placed on the eye. The laser beam is aimed at the anterior portion of the trabeculum, at the junction of the pigmented and nonpigmented trabecular meshwork, and a series of spots is directed onto the trabeculum. In ALT, mild burning is achieved when minor whitening is visible (Figure 3). With SLT, small bubbles are visible upon completion of the laser application. The power and energy required to achieve that goal should be carefully adjusted, starting at a low value and progressively increasing to reach the desired effect.

Postoperatively, antiinflammatory drugs such as topical corticosteroids are given on a regular basis in the hours and days after treatment and then tapered. IOP-lowering drugs such as an alpha-2-adrenergic agent can be administered to prevent IOP spikes after laser treatments.

Complications. Laser impacts aimed at an improper location such as the corneal endothelium or the iris can damage these structures, leading to localized corneal scarring, iris deformation, peripheral anterior synchiae, or bleeding in the most severe cases if the major iris circle arteries or branches of these vessels are ruptured during the procedure. IOP spikes, which are among the most frequent postoperative complications, can be addressed with antiinflammatory drops and/or antiglaucoma medications. Extended or severe anterior segment...
inflammation (ie, uveitis) can be present despite the use of antiinflammatory drugs, and subconjunctival or sub-Tenon injection of slow-release glucocorticoids may be necessary to control such inflammation.

The success rate and duration of effective lowering action of laser trabeculoplasty have been widely discussed. Based on the literature, about 40% to 50% of patients treated with laser trabeculoplasty achieve target IOP within 3 to 4 years after laser treatment. Such treatment can be repeated, although the overall success might not improve after iterative procedures. A decrease in efficiency, initially of 5% to 10% per year, is seen in eyes treated with laser trabeculoplasty, and this may eventually necessitate filtering surgery.

**FILTERING SURGERY**

Filtering surgery aims at lowering IOP by reshaping the filtration pathway, in other words by physically removing a region of high resistance to aqueous outflow. Initially, filtering surgery consisted of removing a portion of the trabeculum (trabeculectomy), and filtration was controlled by the tightness of the scleral flap that acted as a valve, preventing over-filtration and hypotony. The space under the conjunctiva, forming a filtering bleb, drained aqueous humor and helped control the extent of filtration. Complications related to this technique included postoperative hypotony, and nonpenetrating filtering procedures have been developed to alleviate such drawbacks.

The rationale behind nonpenetrating techniques lies in the slow and progressive reduction of IOP by selectively removing the region of high resistance layer by layer, instead of penetrating the anterior chamber and removing a full-thickness portion of the trabeculum. Deep sclerectomy works by creating a thin trabeculo-Descemet membrane (TDM), through which aqueous humor flows with a reduced resistance to egress. Viscocanalostomy, on the other hand, aims to improve the patency of Schlemm canal, after a proper dissection of the ostia and enlargement using an ophthalmic viscosurgical device (OVD). Performing either of these techniques should prevent excessive over-filtration and avoid almost all of the severe postoperative complications encountered after trabeculectomy.

A second aim of the nonpenetrating procedures is to create an intrascleral filtering space that decreases the need for a subconjunctival filtering bleb. The thin remaining scleral bed of the intrascleral bleb also allows part of the aqueous humor to be redirected to the subchoroidal space and thus increase uveoscleral outflow.

**Indications.** Primary open-angle glaucoma, pseudoxfoliative glaucoma, pigmentary glaucoma, normal tension glaucoma, and steroid-induced glaucoma are good indications for nonpenetrating filtration surgery. As with laser trabeculoplasty, good integrity of the iridocorneal structures is required for performing this technique.

Extended apposition of the iris against the trabeculum fully blocks aqueous outflow in complete angle-closure glaucoma. Primary and secondary angle-closure glaucomas represent absolute contraindications for deep sclerectomy. The new vessels growing within the angle structure in neovascular glaucoma form a bulk that also prevents aqueous humor from flowing freely toward the trabeculum, and this is therefore another contraindication.

**Surgical technique.** In nonpenetrating filtering surgery, the conjunctiva and Tenon capsule are opened at the limbus. The surface of the exposed sclera with loose epithelial tissue is scraped with a hockey-stick blade. A 5 X 5 mm, limbus-based superficial scleral flap (one-third of scleral thickness) is created, and a deep scleral flap measuring about 4 X 4 mm is dissected, leaving a thin layer of deep sclera covering the choroid on the posterior plane. The roof of Schlemm canal is removed, and the dissection is carefully extended further into the corneal stroma to remove sclerocorneal tissue (Figure 4). The ostia of Schlemm canal are widened using a thin cannula, and OVD is injected into both openings. The superficial scleral flap is repositioned over a layer of OVD applied on the deep scleral bed, and the flap is sutured. The conjunctiva and Tenon layer are then closed.

Postoperative therapy is based on topical antibiotics and corticosteroids given four to five times per day during the postoperative period and tapered 1 month after surgery. In the early postoperative days, IOP is generally low,
around 2 to 5 mm Hg. One week postoperative, IOP rises around 10 mm Hg.17 Postoperative management consists of preventing scarring of the filtering bleb, which is addressed by bleb needling and injection of an antifibrotic agent next to the bleb. A thickening of the TDM results in a decrease in water conductance, leading to increasing resistance to aqueous outflow and IOP rise. To alleviate this complication, Nd:YAG goniopuncture of the TDM can be performed in the weeks or months after nonpenetrating surgery.

Complications. The main complications that may occur during filtering surgery are common to every ocular surgical procedure and can include hemorrhage, acute inflammatory reaction, persistent and disabling pain, hypertony, malignant glaucoma, hypotony, and infection. More specific to nonpenetrating surgery is the inadvertent perforation of the thin TDM, an event that predominantly occurs during the surgeon’s learning curve. A small perforation of the membrane with maintenance of a deep anterior chamber is not remarkable, and the surgery can be completed normally.

In more severe cases in which the anterior chamber becomes shallow due to a larger crack in the membrane, the iris can protrude through the gap, and the portion entrapped in the breach must be severed, creating a peripheral iridectomy. In such cases, the nonpenetrating procedure is transformed into a classic penetrating trabeculectomy.

IOP can be excessively low for an extended period after filtering surgery, and the cause for such hypotony should be addressed. A leaking filtering bleb with a positive Seidel sign or aqueous misdirection are the most likely causes for low IOP. Bleb revision should be performed in refractory cases.

CONCLUSION

Laser trabeculoplasty is an elegant procedure for lowering IOP in glaucoma patients with elevated pressure. The IOP-reducing effect, although moderate, can help lower IOP by 5 to 10 mm Hg, bringing patients from, for instance, 25 mm Hg to 16 to 18 mm Hg. The relative ease of the technique and the rapid and straightforward nature of the procedure, performed outside the complex sterile and aseptic environment of an operating room, is appealing for some patients who need a therapeutic solution to control IOP other than or in addition to glaucoma medications.

On the other hand, the reduced lifetime of this procedure and its moderate IOP-lowering action are limitations. In the most severe cases, a more robust therapeutic intervention is needed to help preserve the optic nerve. In such instances, filtering surgery should be proposed to reduce IOP to the low 10s mm Hg with long-term efficacy. Filtering surgery should not unduly increase the peri- and postoperative risks of complications, as compared with a laser procedure, and postoperative management should be relatively simple and not put further burdens on the patient.

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