SURGICAL TREATMENT FOR PRIMARY OPEN ANGLE GLAUCOMA

AUTHOR

Jeff Miller: Northeastern State University

PEER REVIEWER

Jane-Ann Grogg: Indiana University

CHAPTER CONTENTS

INTRODUCTION 1
SURGERIES FOR PRIMARY OPEN ANGLE GLAUCOMA 2
LASER TRABECULOPLASTY 2
INCISIONAL TECHNIQUES 5
NON-PENETRATING GLAUCOMA SURGERY 7
CYCLOPHOTOCOAGULATION 9
SURGERY FOR CLOSED ANGLE GLAUCOMA 10
SUMMARY 10
REFERENCES 10

INTRODUCTION

In most cases, glaucoma treatment commences with medication, proceeding to laser therapy followed by more invasive surgery when necessary.

Laser and surgical procedures are indicated when medical management is unable to reduce the damaging high intraocular pressure (IOP) and progressive optic nerve damage and/or visual field loss is detected. In some cases, laser surgery is the first-choice treatment plan, especially in the case where compliance is questioned.

Non-medication options for glaucoma treatment are broadly grouped into the following categories:

- Laser techniques
- Incisional surgery
- Implant surgery

The principal purpose of laser therapy and surgery is to selectively target one or more structures of the eye to reduce the IOP.

The duration that the IOP remains lower following laser treatment depends on many factors including:

- Type of laser surgery
- Type of glaucoma treated
- Age
- Race

The decision to choose laser and surgical interventions focus on the following:

- Ability to achieve and maintain a lowered IOP used in laser pre and post ops such as LPI and SLT
- Retention of an open angle with functional trabecular meshwork (TM)
- Reduced usage of anti-glaucoma medications or as an adjunctive therapy for patients already taking topical glaucoma medications who are not at their target IOP goal.
- Minimization of visual field (VF) loss
- Reduced need for additional surgical procedures
- Minimization of adverse reactions of topical glaucoma therapies, such as chronic dry eye.

When choosing the specific form of treatment or the decision to change treatment, the key consideration must be to minimize the risks and maximize the benefit to the patient.

All forms of treatment for glaucoma have potential for side effects or complications. The impact of the treatment outside of simply its ability to lower IOP must be evaluated.

SURGERIES FOR PRIMARY OPEN ANGLE GLAUCOMA

The main laser and surgical treatments for primary open angle glaucoma (POAG) are as follows:

- Laser trabeculoplasty (LT)
  - Argon laser trabeculoplasty (ALT)
  - Selective laser trabeculoplasty (SLT)
  - Micropulse laser trabeculoplasty (MLT)

- Incisional surgical techniques
  - Trabeculectomy
  - Shunt/valve procedure

- Cyclo-destructive procedures

LASER TRABECULOPLASTY

Trabeculoplasty is a modification of the trabecular meshwork (TM) and employs a laser that produces a focused beam of light to a targeted tissue, in this case the TM. In glaucoma, the aqueous humor drainage system is treated to increase the outflow and thereby reduce the IOP. Depending on the type of glaucoma being treated, laser trabeculoplasty is usually performed before other surgical procedures are attempted.

The procedures are performed in an out-patient environment either in the doctor's office, outpatient surgery center, or in a hospital clinic.

- These include the ALT and SLT procedures
- These are used on patients for the treatment of open-angle glaucoma
- Laser is directed at the trabecular meshwork. An IOP reduction of 20-25% is usually expected but patient may still need medications

ARGON LASER TRABECULOPLASTY

The laser beam is directed toward the TM using a gonioscopy lens with the patient seated at the slit-lamp. In the ALT procedure, the laser beam is directed at the junction of the pigmented and non-pigmented portion of the TM.

In ALT it is usual to treat half the TM first. If necessary, the other half of the TM can be treated in a separate session at a later time. ALT lowers the IOP about 75% of the time but glaucoma medications are still required in most cases.

Adequate control of the IOP following ALT may decrease over time so a follow-up procedure may be required. The procedure may not be as effective when repeated as the subsequent surgeries are less predictable than the first surgery.

How does the ALT work?

There are two major hypotheses regarding the effectiveness of ALT.

- Mechanical hypothesis: when the tissue scars it pulls on the collagen framework and increases the outflow of aqueous
- Biochemical hypothesis: the laser activates macrophages that clean up the TM, and this promotes aqueous outflow
- Or, possibly a combination of both

Procedure for ALT

The procedure for using the argon laser in trabeculoplasty is as follows:

- Place 50 micron size burns between the pigmented and non-pigmented TM (Figure 18.1)
- Space them by two or more burn sizes
- Apply around 50-80 per 180 degrees
- Treat 180 degrees at one sitting
- Using power setting of 300-1000 mW depending on the level of pigmentation

Contraindications of ALT

The ALT technique is contraindicated in patients with the following conditions:

- Inflammatory glaucoma
- Iridocorneal endothelial syndrome (ICE)
- Neovascular glaucoma
- Synechial angle closure
- Developmental glaucoma
- Angle recession

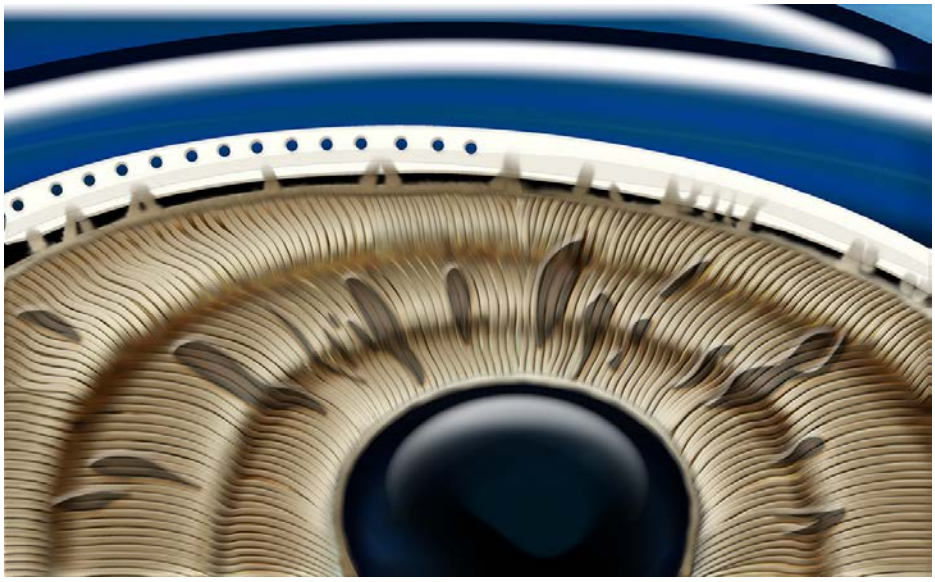

Figure 18.1: *Laser-induced holes at the trabecular meshwork*

SELECTIVE LASER TRABECULOPLASTY

SLT is performed with a Q-switched 532 nm Nd:YAG laser that operates at very low energy levels with a large spot size.

It targets specific pigmented cells (melanocytes) of the trabecular meshwork (TM) in a selective manner, leaving untreated portions of the meshwork intact. The laser settings result in less damage to adjacent TM cells but the SLT procedure can reduce the IOP to a level that is comparable with ALT.

As the SLT procedure does not affect the structure of the TM to the same extent as in ALT, it is possible to do repeat procedures of SLT in a safe and effective manner. The SLT procedure may be a suitable alternative for people who need adjunctive therapy to their topical glaucoma treatments, those who are non-compliant with medications, those who were already treated unsuccessfully with medication or perhaps had unsuccessful ALT.

Procedure for SLT

The procedure for SLT is as follows:

- Q-switched Nd:YAG laser is used
- Apply 400 micron burn size
- Apply burns adjacent to each other
- Focus at the border of anterior and posterior TM
- Deliver 0.4-1.0 mJ of energy over 3-4 nanoseconds

Outcomes

The key outcomes from SLT are as follows:

- Less post-op pain and inflammation
  - Less tissue damage at the TM and less IOP spike
- Short term success good: 6 to 9 mm Hg drop
- IOP may spike a few hours after the procedure
- Medication before and after the surgery to reduce the IOP may be required
- May still need IOP-lowering medication but often less than required before the procedure
- Inflammation of the iris may occur following the procedure

Other Issues with Laser Trabeculoplasty

Some of the other issues regarding LT are as follows:

- Long term success is not guaranteed
- Approximately 30% failure in IOP control in the first year for ALT
- 5-10% failure rate per year
- 66% do not obtain needed IOP level at 5-10 years
- Repeat ALT usually not successful
    - 35% @ 6 months
    - 5% @ 2 years
- If SLT is a successful in lowering a patient's IOP, it is generally thought to be a repeatable procedure should the IOP start to increase over time.
- If excessive scar tissue forms, further surgery may be required
- If glaucomatous damage to the optic nerve continues after the procedure, other surgery may be required

MICROPULSE LASER TRABECULOPLASTY

The technique employed in MLT uses a specific diode laser to deliver energy in short microbursts. MLT provides similar IOP-lowering effects as SLT and ALT.

INCISIONAL TECHNIQUES

FILTERING PROCEDURES

In filtering surgery, the channel from the anterior chamber to the sclera is formed. This allows aqueous humor to pass through the area of removed TM (Figure 18.2) into a sub-conjunctival sac created in the adjacent area. The fluid flows through the surgically-created hole and forms a small blister-like bump called a bleb. The bleb, usually located on the upper surface of the eye, is covered by the upper eyelid and is usually not visible. The aqueous humor is then taken into the body circulation from the bleb.

This technique is also called a fistulizing procedure. Surgery is usually performed with a local anesthetic and sedative. A retro-bulbar injection is used to prevent eye movement. The surgeon will generally perform a 1 day and 1 week post-op check for careful monitoring of the patient's post-surgical complications.

In older patients, glaucoma filtering surgery is successful in about 70-90% of cases, for at least one year.

Occasionally, the surgically-created drainage channel begins to close and the pressure rises again. This occurs because the body tries to heal the new opening in the eye, as if the opening were an injury. This rapid healing occurs most often in younger people, because they have a stronger healing system compared with older patients. Many patients are treated during surgery with an antimetabolite agent in an attempt to prevent aggressive surgical scarring of the bleb.

If needed, glaucoma filtering surgery can be repeated, but the risks, benefits and healthy surface area of the conjunctiva would have to be taken into account.

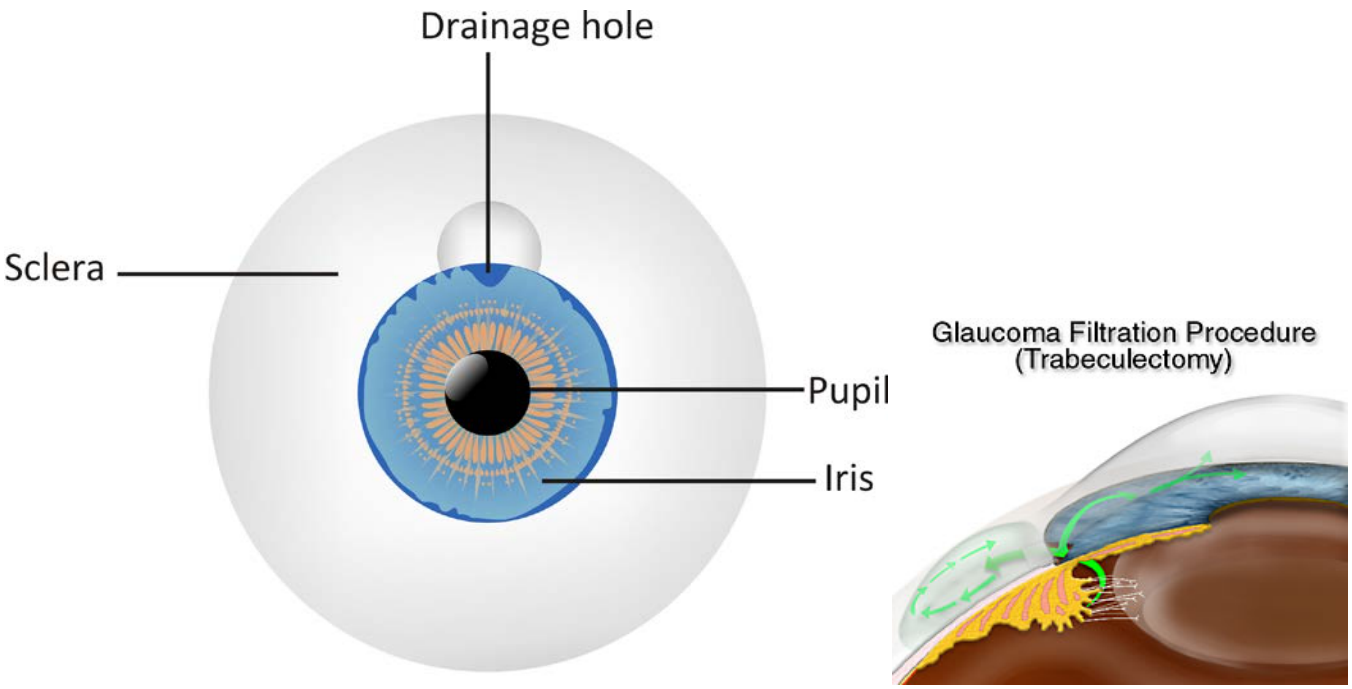

Figure 18.2: *Trabeculectomy for open-angle glaucoma*

COMPLICATIONS OF TRABECULECTOMY

Trabeculectomy is a well-established technique, but it poses significant risk for early and late post-operative complications. The technique has been associated with a number of complications, including the following:

- Early
  - Infection
  - Hypotony
  - Flat anterior chamber
  - Aqueous misdirection
  - Hyphema
  - Formation of cataract
  - Transient IOP elevation
  - Cystoid macular edema
  - Hypotony maculopathy
  - Choroidal effusion
  - Suprachoroidal hemorrhage
  - Persistent uveitis
  - Dellen formation
  - Loss of vision

- Late
  - Leakage or failure of the filtering bleb
  - Cataract development
  - Blebitis
  - Endophthalmitis/bleb infection
  - Symptomatic bleb
  - Bleb migration
  - Hypotony

The use of anti-metabolite therapy, such as 5-fluorouracil (5-FU) and mitomycin-C (MMC), reduces the risk for bleb failure by controlling the formation of scar tissue at the surgical site.

Anti-metabolites are indicated for high-risk patients, such as the following:

- Younger patients
- History of failed filtration surgery
- African-Americans
- Cases of aphakic, uveitic, neovascular or secondary angle closure glaucoma

VISION LOSS AND TRABECULECTOMY

The effect of trabeculectomy on vision is as follows:

- Incidence of vision loss varies from 6-20%
- Decreased VA usually from:
    - Hypotony
    - IOP spike
    - Inflammation

NON-PENETRATING GLAUCOMA SURGERY

Non-penetrating glaucoma surgery creates an outflow pathway without the anterior chamber penetration as occurs in trabeculectomy. This technique reduces the risk of a flat anterior chamber in the immediate post-operative period.

These procedures are considered more difficult to teach, and there is often a steep learning curve for surgeons.

Non-penetrating surgeries do not usually result in the formation of a filtering bleb, and patients have fewer complaints because of the absence of the bleb. However, studies evaluating non-penetrating glaucoma surgery show that IOP reduction is generally less than that achieved with trabeculectomy.

GLAUCOMA TUBE SHUNT

A glaucoma drainage device (GDD) consists of an endplate of varying surface area and design that is inserted into the sub-conjunctival space. The end-plate is attached to a drainage tube inserted into the anterior chamber or the posterior chamber via the pars plana.

This drainage tube may offer little resistance to aqueous flow (such as Baerveldt, Molteno) or may be constructed with a unidirectional valve (such as Ahmed, Krupin).

Non-valved drainage implants require the insertion of a removable stent within the tube or a ligature around the tube to prevent immediate post-operative hypotony. Drainage implants can reduce IOP 50% below pre-operative levels. However, they are also associated with complications including the following:

- Hypotony
- Corneal decompensation
- Encapsulation of the end-plate
- Erosion of the tube
- Suprachoroidal hemorrhage
- Diplopia

Drainage implants, or tube shunts, have traditionally been reserved for patients who have uncontrolled IOP and a history of failed filtration procedures, scleral buckling surgery, extensive conjunctival scarring or exaggerated inflammatory response (neovascular or uveitic glaucoma).

Implants for glaucoma treatment are being done more commonly, and in some cases are used as a primary filtration surgical modality. Results from the Tube versus Trabeculectomy Study (TVT) indicate that both procedures produced approximately equal IOP reduction at the end of the first year, but patients more often required the use of supplemental medication to reach acceptable IOP following the placement of a non-valved GDD.

Various devices can be used for these glaucoma surgeries including the following:

- Molteno and Baerveldt designs
- Krupin and Ahmed (Figure 18.3) designs

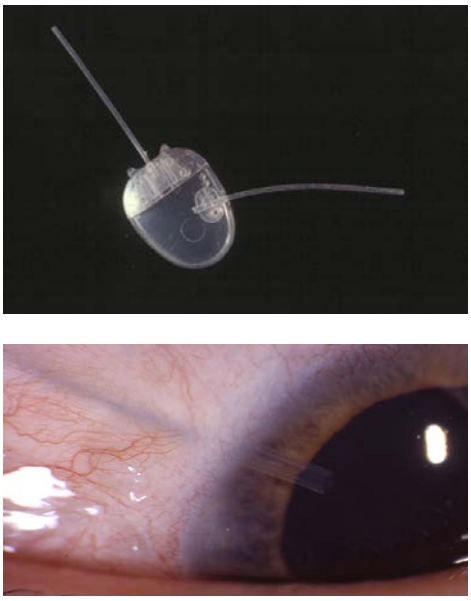

Figure 18.3: *Ahmed valve*

CANALOPLASTY

This is a non-penetrating procedure utilizing micro-catheter technology.

In canaloplasty with tensioning suture, Schlemm's canal is circumferentially dilated with Healon GV (sodium hyaluronate) using a micro-cannula (200 microns diameter). An optic fiber allows the microcatheter to be viewed through the sclera. Once the canal has undergone visco-dilation, a 10-0 Prolene suture is attached to the cannula and advanced through the canal as the cannula is withdrawn. This suture creates tension on the TM, bringing it anteriorly to reduce resistance to outflow and thereby reducing IOP.

Advantages of canaloplasty include the following:

- Improved safety profile over trabeculectomy.
- Can be combined with cataract surgery to further reduce IOP
- Study results demonstrate a significant and sustained reduction in both IOP and the number of medications required for glaucoma control.

TRABECTOME SURGERY

The Trabectome (NeoMedix, Tustin CA) accesses existing outflow channels by creating a direct communication between the anterior chamber and Schlemm's canal.

This trabeculotomy procedure combines an electro-surgical device with irrigation, aspiration and a protective footplate to ablate and remove TM tissue and the inner wall of Schlemm's canal.

Presumably this procedure clears out some debris and incites a macrophage influx.

Transient intra-operative hyphema due to blood reflux into Schlemm's canal is the most common complication of this procedure.

Initial results are promising, with IOP controlled in the 15 to 16 mm Hg range. There is no bleb formation or risk for flat anterior chamber, and the perilimbal conjunctiva is preserved if further surgical intervention is required.

ISTENT PROCEDURE

A micro-invasive procedure that restores the conventional outflow pathway by bypassing TM resistance is the iStent (Glaukos Corp., Laguna Hills, CA). This trabecular bypass micro stent is an L-shaped titanium tube measuring 120 microns in diameter that is implanted into Schlemm's canal using a tiny opening through the TM.

The lumen of the stent restores aqueous flow from the anterior chamber into Schlemm's canal. Prospective clinical studies demonstrate post-operative intraocular pressures of 15-16 mm Hg at 12 months.

No bleb is formed and the placement of the iStent preserves all future options for glaucoma filtering surgery. Multiple implants may be used to further reduce IOP and to achieve the IOP reduction based upon individual patient target pressures.

SOLX GOLD SHUNT

The Solx Gold Shunt is a 60 micron wafer made of two gold plates that is designed to increase uveoscleral outflow by redirecting fluid from the anterior chamber to the suprachoroidal space.

This device makes use of the negative pressure differential between these two areas and explores another pathway to increase aqueous outflow.

CYCLOPHOTOCOAGULATION

It is possible to retard the ciliary body's ability to make aqueous humor and, thus, lower the IOP. Cyclophotocoagulation is usually used to treat advanced open-angle glaucoma. It is usually used only after other treatments have been unsuccessful.

Trans-scleral cyclophotocoagulation is a form of laser therapy which treats glaucoma by damaging the ciliary body to decrease aqueous humor production.

Currently, cyclo-destructive procedures are commonly performed using a trans-scleral laser delivery system, however they can also be performed endoscopically (Pastor et al 2001, cited in American Academy of Ophthalmology [AAO] 2005b).

These procedures may need to be repeated in order to control glaucoma adequately.

RISK OF CYCLOPHOTOCOAGULATION

For people who require cyclophotocoagulation surgery, there is a risk of the IOP dropping too low to maintain normal metabolism and shape of the eye.

ENDOSCOPIC CYCLOPHOTOCOAGULATION (ECP)

The main features of ECP are as follows:

- Ciliary body partially ablated by probe
- Often done in conjunction with cataract surgery
- Patients include:
    - Those with poor compliance (dementia, etc)
    - Neovascular glaucoma cases
    - Chronic angle closure patients

CILIARY BODY ABLATION

When the eye is blind and the patient's IOPs are too high, it is possible to consider killing off the ciliary body (CB). This may be done with the cryo-probe and the CB is frozen by applying the probe to the sclera approximately 1-2 mm from the limbus.

This is a very painful procedure and is usually the last resort in the treatment of glaucoma.

COMBINED PROCEDURES

Procedures such as blebs, shunts and ECP are often done in combination with cataract surgery. This limits the number of intra-ocular surgeries the patient has to endure.

SURGERY FOR CLOSED ANGLE GLAUCOMA

The main surgical technique for closed angle glaucoma is laser peripheral iridotomy (LPI).

LASER PERIPHERAL IRIDOTOMY

LPI is a treatment for narrow angles or angle-closure glaucoma.

LPI is performed with either an argon or Nd:YAG laser. The laser makes a small hole or puncture in the iris, allowing the iris to retreat away from the TM. Opening the aqueous humor outflow channels thereby reduces the IOP.

SUMMARY

Surgery offers many options in glaucoma management and will continue to evolve with the development of new imaging techniques and materials. The ultimate goal of surgical intervention is to achieve long term IOP control with low risk of surgical complications and other adverse events.

REFERENCES

- Shields' Textbook of Glaucoma, 5th ed. Allingham RR, et al.
- Medical Management of Glaucoma , 3rd ed. Tsai JC, Forbes M