Non-Penetrating Glaucoma Filtering Surgery—An overview

Manish Panday, MS, Ronnie George, MS

Introduction

Trabeculectomy remains the standard surgery for intraocular pressure control for glaucoma. It involves a full thickness penetration of sclera, to allow aqueous seepage to subconjunctival space under a scleral flap. However, it carries the risk of serious bleb related complications like overfiltration, hypotony and consequent persistent choroidal detachment, shallow anterior chamber, cataract, peripheral anterior synechiae or decreased vision from hypotonous maculopathy. Moreover, bleb leaks increase the risk of bleb infection and endophthalmitis.

Interest in non penetrating glaucoma surgery (NPGS) evolved in avoiding the complications of a full thickness procedure. These techniques mainly target the outer trabecular meshwork at the site of maximum resistance to aqueous outflow. Other possible mechanisms include transscleral flow, uveoscleral outflow and opening of non functional areas of Schlemm’s canal. Various surgical techniques have been described for the same, which we try to subsequently analyze in this article.

Discussion

NPGS evolved during the late 1950’s and early 1960’s by Epstein1 and Krasnov2. However, its popularity as an effective treatment for IOP control was limited due to concurrent introduction of trabeculectomy as a relatively easier and more effective procedure to perform than NPGS. Recent renewed interest in NPGS lies in overcoming these previous drawbacks.

Surgical Techniques

Deep Sclerectomy

After adequate anaesthesia, a superior rectus or corneal traction suture is placed and a fornix or limbus based conjunctival flap is created. A partial thickness (one third to half thickness) limbus based scleral flap measuring 5mmx 5 mm is dissected 1.5 mm into the clear cornea. A deeper (upto 90% depth) second scleral flap measuring 4mm x 4 mm is then dissected forwards in the plane of scleral spur and Schlemm’s canal. The Schlemm’s canal is identified and unroofed for approximately 3 mm long at the level of scleral spur. Cleavage is taken forwards between the corneal stroma and Descemet’s membrane. This deeper scleral flap is subsequently excised to form a ‘scleral lake’ for pooling of aqueous. This leads to the formation of a ‘trabeculo-Descemet’s membrane’ (TDM) as the outflow resistance for aqueous. Evidence of flow through this TDM is mandatory at this point. To improve outflow, inner wall of Schlemm’s canal can be removed and juxtacanalicular meshwork can be gently peeled with blunt forceps. Use of mitomycin c in the scleral bed and use of space maintainer implants (Aqua flow, T Flux, SKGEL and PMMA) have been described. The scleral flap is loosely sutured with two 10-0 nylon sutures and the conjunctiva and Tenon’s capsule are closed in layers. Since deep sclerectomy involves filtration and formation of a bleb, modulation by means of postoperative 5-Fluouracil injections have been described along with Nd-YAG goniopuncture of the TDM in the postoperative phase; which converts this into a full thickness procedure.

Viscocanalostomy

As a variant of NPGS, viscosonalostomy involves injecting high viscosity viscoelastic in the Schlemm’s canal, after unroofing the Schlemm’s canal. Peeling of inner wall of Schlemm’s canal and juxtacanalicular TM is not suggested. Aqueous seepage from the TDM is thus forced to reach the ostia of Schlemm’s canal. Viscoelastic is also placed in the ‘scleral lake’ preventing collagen cross linking. The first scleral flap is tightly sutured as opposed to deep sclerectomy and thus there is no filtering bleb in this procedure. The conjunctiva and Tenon’s capsule are closed in layers.

An alternative technique of dilation of Schlemm’s canal has been described using an illuminated optical fiber microcatheter. Following exposure of Schlemm’s canal, the catheter is passed circumferentially around the Schlemm’s canal under direct visualization. High viscosity hyaluronic acid is injected to dilate the Schlemm’s canal every 2 clock hours. A 10- Nylon suture is affixed to the end of the catheter which is subsequently withdrawn. The suture is then tied resulting in 360 degree dilation of the canal. The scleral flap and conjunctiva are subsequently closed as above.

NPGS is a more challenging surgical procedure as compared to trabeculectomy, requiring increased surgical time and a prolonged learning curve. Besides, risk of perforation of the TDM requiring conversion to conventional trabeculectomy has prompted development of alternative techniques. Recently, carbon dioxide laser (CO2 laser) has also been used for photoablation of the scleral bed after fashioning a 5x5 mm superficial scleral flap. This laser has the unique property of being absorbed by a thin layer of water. The laser beam is focused on an area overlying the Schlemm’s canal and ablation is continued till obvious percolation of aqueous through the scleral bed is seen. At this point, the residual
trabecular meshwork is protected by the effect of laser due to aqueous percolation. Thus the chances of perforation into the anterior chamber are minimized. The superficial scleral flap is secured loosely with 10-0 Nylon sutures and the conjunctiva and Tenon’s capsule are closed in layers.

**Mechanism of action**

**Deep Sclerectomy:** Aqueous percolates through the TDM into the scleral lake and then to subconjunctival space. Resultant blebs are usually shallower and more diffuse. Alternative pathways for drainage include suprachoroidal space, via the cut ends of Schlemm’s canal and through the intrascleral bleb.

**Viscocanalostomy:** This procedure results in dilation of Schlemm’s canal and associated collector channels, resulting in enhanced drainage through this route. In addition, damage to endothelium of Schlemm’s canal results in communication of juxtaocular area to Schlemm’s canal.

**Indications and Contraindications**

NPGS is usually indicated in open angle glaucomas—whether primary or secondary (especially pigmentary and pseudoexfoliative). Angle closure glaucomas are a relative contraindication as clinical decision depends on degree of synechial closure of the trabecular meshwork. Iridocorneal endothelial syndrome (ICE) and eyes with congenital or juvenile glaucomas with angle anomalies and scleral thinning are contraindications to NPGS. Neovascular glaucomas constitute an absolute contraindication due to invasion of the angle and trabeculum with neovascular vessels and subsequent loss of filtration.

The amount of IOP reduction achieved with NPGS is usually lower than that by trabeculectomy. NPGS may be more suited when target IOP is in mid to high normal range. It may be a procedure of choice in patients with high risk of choroidal haemorrhage or postoperative hypotony. Currently, evidence is lacking in regards to choice of a particular procedure for a specific patient.

**Postoperative complications**

In general, NPGS has been shown to be associated with fewer complications as compared to trabeculectomy. The commonest intraoperative complication is perforation of the TDM. Smaller ones causing no anterior chamber shallowing and iris prolapse can be ignored, larger ones require conversion to conventional trabeculectomy. A steep learning curve has been reported in many studies and conversion rates come down with time.

Early postoperative hypotony with a deep anterior chamber is a good prognostic indicator. IOP tends to stabilize over time. Early postoperative raised IOP may be due to insufficient leakage though TDM or may be viscoelastic induced (in combined surgeries/ AC reformations). Nd-YAG goniopuncture can be attempted in case of insufficient leak through TDM. Rupture of the fragile TDM can also occur in case of Valsalva maneuver or by trauma/ rubbing of eyes with consequent iris prolapse and raised IOP. Peripheral anterior synechiae can also cause late raised IOP. Other reported complications include Descemet’s membrane detachments, cataract and scleral ectasia.

**Outcomes of NPGS**

Stegmann et al first reported the results of viscocanalostomy in 214 eyes of 157 black patients with open angle glaucoma. The mean baseline IOP was 47.4±13.0 mm Hg and mean postoperative IOP was 16.9±8.0 mm Hg at a follow up of 35 months. Bleb formation was seen in 5% patients with minimal complications reported. Postoperative IOP of 22 mm Hg or less was achieved in 82.7% of patients.

The ophthalmic technology assessment committee of American Academy of Ophthalmology reviewed 33 articles related to NPGS from 1968 to 2000. They reported a mean postoperative IOP lowering to high normal range in NPGS with fewer complications due to overfiltration and hypotony as compared to trabeculectomy with no evidence of prevention of progressive glaucomatous optic neuropathy.

In a meta-analysis of 22 studies of deep sclerectomy and 14 with viscocanalostomy from January 2000 to August 2005, Hondur A et al reported 48.6% patients achieving an IOP of 21 mm Hg or less with primary deep sclerectomy (without antimetabolite use/ implants), the rate of goniopuncture being from 4.6% to 40%. In contrast 51.1% patients after primary viscocanalostomy achieved a final postoperative IOP of at least 21 mm Hg after 25.6 months with goniopuncture rate from 4.1% to 56%. However, most series did not report the severity of glaucoma. The authors stressed the need for data regarding glaucoma severity, visual fields in particular and an individualized target IOP to assess the efficacy and success of any surgical therapy. These success rates would also reflect post operative bleb modulations by means of goniopuncture and antimetabolite use.

Wide variation in reported success rates are also attributed to the long learning curve as well as varied surgical techniques in NPGS. Use of implants and antimetabolites in surgery is generally reported to increase the success rates. In a prospective randomised study of 26 eyes of 13 patients with open angle glaucoma, Shaarawy et al reported a complete success rate of 38% in deep sclerectomy alone versus 69% in those with adjuvant collagen implant at 48 months. A complete success was defined as IOP < 21 mm Hg without medications. The mean IOP was 16 mm Hg for the former and 10 mm Hg for the latter group at 48 months.

Both deep sclerectomy and viscocanalostomy can be
combined with cataract surgery. Moreno-Lopez M et al in a retrospective review of 15 eyes of 12 patients showed IOP control at median of 12 months with 80% patients having IOP <17 mm Hg following cataract surgery with deep sclerectomy.

The short term efficacy of newer techniques such as carbon dioxide laser NPGS appear promising, though long term results need to be looked for in terms of IOP control and complications.

**Conclusion**

In general, surgical therapy in glaucoma is resorted to in failure of medical therapy. This results from the fact that the current gold standard therapy in form of trabeculectomy may result in varied intraoperative and post operative complications. However, medical therapy over prolonged period of time may also result in conjunctival remodelling and has cost concerns. Though NPGS continues to evolve for the past 50 years and the intraocular pressure achieved is in a higher range as compared to standard trabeculectomy, it may have a role in early glaucomas where modest IOP control may be required besides avoiding complications from a full thickness procedure.

**References**


Figure 1, 2, 3: After dissection of the scleral flap, the laser beam being focused at the scleral bed (red dots) and repeated applications are attempted till obvious percolation of aqueous is seen. The anterior chamber depth is maintained throughout the procedure. Note the ACM in this case.

Figure 4: Diffuse bleb 1 month postoperative with deep AC, IOP 10 mm Hg after carbon dioxide laser NPGS on a patient with baseline IOP 26 mm Hg with POAG.