

The New Glaucoma Surgeries

Nonpenetrating surgery and novel, investigational, Schlemm's canal shunting devices reduce dependence on the healing whims of the conjunctiva.

BY THOMAS W. SAMUELSON, MD

Trabeculectomy (more aptly termed *guarded filtration surgery*) has long been the procedure of choice for glaucoma surgery. Indeed, few alternative procedures have legitimately challenged trabeculectomy since Cairns¹ described the procedure in 1968. For example, despite a few proponents in the early 1990s, holmium laser sclerostomy quickly came to be considered yet another unguarded procedure that risks hypotony unnecessarily while leaving the eye vulnerable to conjunctival fibrosis and scarring. Cyclophotocoagulation is generally reserved for end-stage disease and is a last resort when delivered by the transscleral method. The procedure has been resuscitated, however, by means of an endoscopic delivery system, which some ophthalmologists advocate using early in the course of glaucoma management. Nevertheless, a well-conceived study comparing endoscopic cyclophotocoagulation with trabeculectomy has not yet been completed. Trabeculectomy with antimetabolites and timely suture lysis or suture release has therefore re-

mained the gold standard for the surgical management of glaucoma.

Although this procedure is highly successful, some filtration blebs are prone to long-term risks such as late leaks or bleb-related endophthalmitis (Figure 1). The life-long risk of the latter fuels glaucoma specialists' search for a new operation. The ideal procedure would depend less on the conjunctiva, considered the Achilles' heel of trabeculectomy by many ophthalmologists. In its natural state, the conjunctiva is prone to fibrosis, encapsulation, and ultimate bleb failure. When modified by antimetabolites such as mitomycin C (MMC), bleb fibrosis is much less common. Nevertheless, the conjunctiva may break down years later, thus increasing the risk of late leaks and infection. Moreover, early postoperative complications may occur due to difficulty with titration of aqueous flow through the trabeculectomy site.

This article examines some of the newer outflow procedures such as nonpenetrating filtration surgery and surgery involving Schlemm's canal.

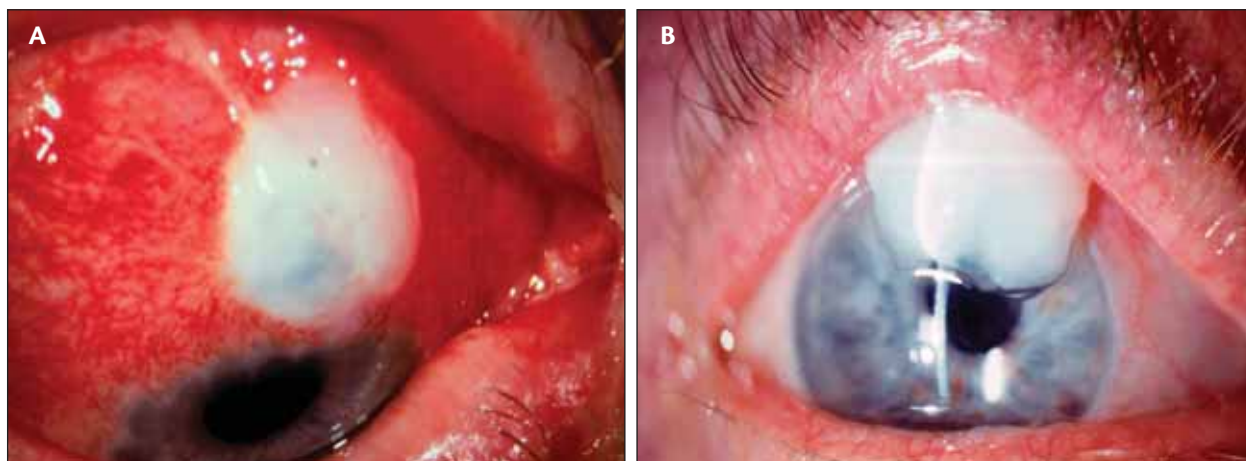


Figure 1. Bleb-related endophthalmitis (A) and undesirable bleb morphology/dysesthesia (B) are two complications of conjunctiva-dependent filtration surgery such as trabeculectomy.



Figure 2. The cannulation of Schlemm's canal is an integral step of viscocanalostomy and Aquaflow surgery.

BACKGROUND

Elevated IOP is the most important known risk factor for glaucoma, and reducing IOP is the only proven treatment for the disease. High IOP results from increased resistance to aqueous outflow through the trabecular meshwork. The site of the pathologically increased resistance to outflow is generally believed to be in the juxtacanalicular portion of the trabecular meshwork.² The outflow system distal to the juxtacanalicular meshwork (primarily Schlemm's canal and the distal collector channels) is thought to be normal in patients with glaucoma.

Trabeculectomy diverts aqueous from the anterior chamber into the subconjunctival space. This procedure completely bypasses the eye's physiologic outflow system, including both the diseased and healthy portions. The filtration bleb that results from trabeculectomy serves as a reservoir for aqueous within the subconjunctival space.

NONPENETRATING FILTRATION SURGERY

Overview

The physiologic premise of nonpenetrating filtration surgery is to improve the eye's outflow facility by bypassing the trabecular meshwork while still using the distal outflow system. A potential advantage of redirecting aqueous into the distal collector channels is that a successful outcome depends less on the formation of a filtration bleb. The degree to which nonpenetrating filtration surgery relies on a subconjunctival collection of aqueous varies among the different nonpenetrating procedures. For example, viscocanalostomy diverts aqueous into Schlemm's canal, thus keeping the aque-

ous subscleral. Nonpenetrating deep sclerectomy with a collagen implant (Aquaflow Collagen Glaucoma Drainage Device; Staar Surgical Company, Monrovia, CA) is somewhat of a hybrid procedure: it both diverts aqueous into Schlemm's canal and allows some trans-scleral filtration and bleb formation.

Viscocanalostomy

The recent resurgence of viscocanalostomy has been largely based on the work of Stegmann,³ who described a high success rate in South African patients perceived to be at high risk of failure for trabeculectomy. His working hypothesis is based on his belief that procedures relying on the conjunctiva are doomed to failure in certain high-risk patients. The initial steps of viscocanalostomy are similar to those of trabeculectomy. Specifically, the surgeon creates a one-half- to two-thirds-depth superficial scleral flap, within the bed of which a deep scleral flap is made. The deep dissection begins 4 to 5 mm posterior to the limbus and advances toward the limbus in a tissue plane just above the suprachoroidal space. As the dissection advances anteriorly, the roof of Schlemm's canal is removed. The surgeon then cannulates Schlemm's canal and injects a bolus of viscoelastic material into each of the canal's cut ends (Figure 2). This viscodissection is intended to dilate the canal and facilitate the subsequent drainage of aqueous. In a primate model and cadaver eyes, Smit et al⁴ demonstrated that injecting viscoelastic into Schlemm's canal results in marked dilation of the canal for 14 to 16 mm from the injection site. They speculated that the resultant ultrastructural changes to the inner and outer walls may augment outflow facility via conventional as well as uveoscleral outflow pathways.

After viscodissecting Schlemm's canal, the surgeon carries dissection of the deep flap farther onto the cornea. This step creates an exquisitely thin trabeculo-Desemet's window that allows the egress of aqueous from the anterior chamber. The creation of this window is primarily responsible for the improved outflow of aqueous from the eye and represents the trabecular-bypass portion of the procedure. The aqueous passes through the window and enters the space created by excision of the deep scleral flap to collect in what is called the *subscleral lake*. From there, the aqueous enters Schlemm's canal and ultimately reaches the distal collector channels.

Theoretically, a successful viscocanalostomy lowers IOP by bypassing the diseased portion of the outflow system. Unlike trabeculectomy, however, the diverted aqueous is directed back into the healthy distal outflow channels. An external filtration bleb is therefore unnecessary.

Nonpenetrating Deep Sclerectomy With Collagen Implant

Several features of this surgical modality are virtually identical to viscocanalostomy—specifically, the creation of the superficial and deep scleral flaps and the trabeculo-Descemet's window. Classically, the surgeon does not perform viscodissection of Schlemm's canal. The primary site of aqueous egress is via the trabeculo-Descemet's window. One additional component of this procedure is the removal of the inner wall of Schlemm's canal, a step performed after the canal is unroofed by the deep dissection. With a fine forceps, the surgeon peels the inner wall from the region of the dissection. A recent report confirmed that this tissue layer contains the juxtacanalicular tissue consistent with the inner wall of Schlemm's canal.⁵ Given that the inner wall of the canal is the site of the pathological increased resistance to outflow,² this maneuver may be additive to the trabeculo-Descemet's window in improving the outflow facility of the eye. Finally, the surgeon sutures the collagen implant into the bed of the subscleral lake to help maintain this space for 6 to 9 months postoperatively. Unlike viscocanalostomy, nonpenetrating deep sclerectomy with implant results in bleb formation. The bleb is lower, more diffuse, and thicker-walled than the one that results from trabeculectomy with antimetabolite use, however.⁶

Results

Shaarawy et al⁷ recently published their 5-year results with viscocanalostomy. The mean preoperative IOP in this series of 57 eyes (57 patients) with medically uncontrolled primary and secondary open-angle glaucoma was

24.6 mm Hg. The mean postoperative IOP was 5.67 mm Hg at day 1 and 13.6 mm Hg at 36 months. Ninety percent of patients achieved IOPs below 21 mm Hg with or without medications at 60 months. Carassa et al⁸ reported the 2-year results of a prospective, randomized trial comparing trabeculectomy with 5-fluorouracil (administered by postoperative, subconjunctival injections) and viscocanalostomy. They observed lower IOPs after trabeculectomy with 5-fluorouracil but fewer complications with viscocanalostomy.

In another comparative study of viscocanalostomy and trabeculectomy by Kobayashi et al,⁹ one eye of each subject was randomized to trabeculectomy with MMC, and the fellow eye underwent viscocanalostomy. IOP was measured at 3, 6, and 12 months. The investigators found trabeculectomy with MMC to be more effective in lowering IOP at all time intervals. Moreover, 88% of trabeculectomy patients were medication-free at 12 months compared with 64% of patients who underwent viscocanalostomy. Fewer complications occurred in the viscocanalostomy group, however. Luke et al¹⁰ and O'Bart et al¹¹ independently reported the 1-year results of their prospective, randomized comparisons of viscocanalostomy and trabeculectomy. Both groups observed lower IOPs with trabeculectomy but fewer complications with viscocanalostomy.

Shaarawy et al⁶ reported the 5-year results of deep sclerectomy with collagen implant. This prospective, nonrandomized trial of 105 eyes found that the procedure provided "reasonable" IOP control with few complications. The mean number of medications was reduced from 2.3 ± 0.76 to 0.49 ± 0.72 . Ninety-five percent of patients' IOPs were controlled overall, and 62% of patients achieved IOP control without medications.

Nearly all of these investigators emphasized the importance of YAG laser goniopuncture to augment filtration in nonpenetrating surgery. During this procedure, YAG laser energy is delivered via a goniolens to the trabeculo-Descemet's window in order to enhance the flow of aqueous from the eye. Goniopuncture is often necessary to obtain an adequate IOP with nonpenetrating surgery, much as argon laser suture lysis or suture release is needed after standard trabeculectomy.

TRADITIONAL AQUEOUS SHUNTING DEVICES

Traditional shunting devices such as the Molteno Implant (Molteno Ophthalmic Limited, Dunedin, New Zealand), Baerveldt glaucoma shunt (Advanced Medical Optics, Inc., Santa Ana, CA), and the Ahmed Glaucoma Valve (New World Medical, Inc., Rancho Cucamonga, CA) are placed in the eye via either an anterior chamber



Figure 3. The EyePass Glaucoma Implant shunts aqueous from the anterior chamber into Schlemm's canal.

or pars plana approach. The tubes communicate with a reservoir sutured to the sclera in the subconjunctival space, near the equator of the globe. Such drainage devices are indicated in situations where a standard trabeculectomy would be expected to fail. By bypassing the scarred conjunctiva in the region of the limbus, aqueous drainage devices often provide successful filtration in high-risk eyes.

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Additional advantages of these shunts include the fact that they are less prone to bleb-related infection, more amenable to contact lens wear, and less likely to generate bleb dysesthesia compared with trabeculectomy. Among their disadvantages are a laborious operation, the risk of postoperative diplopia due to interference with the recti muscles, and possible corneal decompensation. A multicenter, randomized study comparing the aqueous drainage devices to trabeculectomy is currently underway.

NOVEL SHUNTING DEVICES

Two new shunting devices currently in FDA trials are designed to lower IOP by shunting aqueous from the anterior chamber directly into Schlemm's canal. The iStent (Glaukos Corp., Laguna Hills, CA) is inserted into Schlemm's canal via an ab-interno, transcameral approach. Placed via an ab-externo approach, the EyePass Glaucoma Implant (GMP Companies, Inc., Ft. Lauderdale, FL) is a bidirectional shunt that diverts aqueous from the anterior chamber directly into Schlemm's canal (Figure 3). Both shunting procedures offer potential benefits similar to those of viscocanalostomy in that they lower IOP without the formation of a filtering bleb. They therefore do not rely on the cooperation of the conjunctiva for success. One possible advantage of the iStent and the EyePass over viscocanalostomy is that their placement does not require creation of the exquisitely thin trabeculo-Descemet's window to allow the egress of aqueous. Creating this window is generally considered the most challenging aspect of nonpenetrating filtration surgery. Moreover, the flow of aqueous through an open stent is likely to be more predictable than flow across the trabeculo-Descemet's window.

SUMMARY

The goal of controlling IOP via a procedure that does not depend on the conjunctiva is worth pursuing. The ideal procedure would (1) use the healthy portions of the outflow system and bypass the diseased portions, (2) control IOP without the risks of a thin-walled bleb, (3) reduce the risk of hypotony during the perioperative period, and (4) provide adequate IOP control for the life of the patient.

Thus far, nonpenetrating surgery has been moderately successful in lowering IOP. In most reports to date, the final IOP has been higher than that achieved with trabeculectomy, although the complication rate appears to be lower. Slightly higher postoperative IOPs and the surgical modality's technically demanding nature remain the primary obstacles to its widespread acceptance. Additional long-term results will enable ophthalmologists to assess whether viscocanalostomy, nonpenetrating deep sclerectomy with implant, and/or implantation of the new shunting devices will supplant trabeculectomy as the procedure of choice for refractory glaucoma. □

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