Advances in Glaucoma Treatment and Management: Surgery

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Ever since the first glaucoma surgery in 1856, the goal has been to decrease intraocular pressure (IOP), the only modifiable risk and prognostic factor for glaucoma. Over the years, reduction of IOP has been achieved by surgical manipulation of the aqueous inflow or outflow pathways. The glaucoma surgeries that have been developed to affect the inflow pathway have involved the destruction of the ciliary body, the tissue that makes the aqueous, whereas those that affect the aqueous outflow pathway involve either internal or external filtration. With internal filtration, the outflow pathways are manipulated so that they function better; with external filtration, the eye’s natural outflow pathways are bypassed. After the introduction of prostaglandin analogue medications in 1996, the frequency of all types of glaucoma surgery decreased, including the most common type, argon laser trabeculoplasty. In early 2000, a new type of laser surgery, selective trabecuoplasty, was developed and was reported to be less destructive than argon laser trabeculoplasty. Since then, the frequency of laser trabeculoplasty procedures has gradually increased to pre-prostaglandin-analogue levels (personal communication, H. Dunbar Hoskins, Jr, MD, Center for Quality Eye Care, June 6, 2011).

The most frequently used intraocular surgery for glaucoma has been the trabeculectomy, which involves the creation of a partial-thickness scleral flap over a sclerectomy into the anterior chamber. Although this type of external filtration has been regarded as safer than the prior full-thickness sclerectomy, which does not have a partial-thickness flap limiting the flow of aqueous out of the eye, several new surgeries have been developed with the goal of improving on or replacing the trabeculectomy. Thus, in many new-device trials, the standard with which the new device or surgery is compared is a trabeculectomy. Since many of these studies have limitations, of which clinicians should be aware, the goal of this article is to review some of the most recent advances in incisional glaucoma surgery.

In a literature review of trabeculectomies, Rotchford and King1 identified 100 studies published between 2000 and 2005. Only 31 were randomized clinical trials; 53 were retrospective series. The best evidence for supporting clinical decisions is from randomized clinical trials, which involve the random assignment of patients to one procedure or another, an approach that prevents unknown biases from changing or affecting the results. Without randomization, it is difficult to know whether one procedure is better than another. In the 100 studies, there were 92 distinct IOP-related definitions of success, making it very difficult to compare the results of the studies, in which success rates ranged between 36% and 98% after 3 years of follow-up. Such a wide range of expectations for success makes it very difficult for a surgeon to obtain consent from a patient. The drive to create a better or different surgical procedure to lower IOP arises not only from the limited success rates of trabeculectomies but also from the short- and long-term risks of endophthalmitis (ocular infection) and ocular hypotony (too low IOP) after trabeculectomy.

Unfortunately, 99 of the 100 studies did not report information on either visual function or optic nerve progression parameters. Although lowering of IOP is often used as a surrogate treatment goal for glaucoma management, the ultimate goal is to preserve visual function. Without information on visual function before and after surgery or across surgical groups, assessment of the success of the surgery is limited to IOP and thus does not capture the whole story.

Manipulation of Aqueous Inflow

Although ciliary body destruction was suggested as a way to lower IOP in glaucoma patients in the 1930s, endocyclophotocoagulation (ECP) was not introduced until the 1990s. ECP involves the use of an endoscopic probe that allows the surgeon to visualize the ciliary processes and to coagulate or burn via the probe with a laser. In a recent study by Gayton et al.3 58 eyes of 58 patients who underwent cataract extraction were treated with ECP or a trabeculectomy. The definition of complete success was an IOP <19 mm Hg without the use of glaucoma medications. At 1 year, 42% of eyes with a trabeculectomy had complete success; 30% of eyes with ECP had complete success. Because cataract surgery alone may reduce IOP, information on the additional benefit of trabeculectomy or ECP is not provided in this study. In another randomized trial of 68 eyes with refractory glaucoma, ECP and a drainage device had a similar cumulative probability of success at 24 months (P = 0.7).4 Although visual functioning before and after surgery or between study groups was not compared, the results of both randomized trials lend support to the conclusion that ECP is similar to trabeculectomy and drainage devices in lowering IOP.

Manipulation of Aqueous Outflow

External Filtration

The 1970s saw the introduction of the Molteno implant, a drainage device involving a small tube that is inserted into the eye and drains the aqueous from the eye to a plate placed under the conjunctiva. Since then, there have been numerous modifications to the tube and plate design, including the development of valve-like mechanisms and plates with larger surface area and filtration holes to limit the height of the fluid-filled capsule that forms around the plate. There have been two randomized clinical trials comparing different drainage devices to trabeculectomy. Wilson et al.5 compared the Ahmed
<table>
<thead>
<tr>
<th>Authors</th>
<th>Comparison Groups (Sample n)</th>
<th>Definition of Complete Success (No Glaucoma Medications)</th>
<th>Proportion with Complete Success</th>
<th>Definition of Qualified Success (with or without Glaucoma Medications)</th>
<th>Proportion with Qualified Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gayton et al.³</td>
<td>Cataract extraction with ECP (29)</td>
<td>IOP &lt; 19 mm Hg without glaucoma medication</td>
<td>30%/1 y with ECP</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Lima et al.⁴</td>
<td>Cataract extraction with trabeculectomy (29)</td>
<td>IOP &lt; 21 mm Hg and at least 15%</td>
<td>42%/1 y with trabeculectomy</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Ahamed implant (34)</td>
<td>Ahmed implant (34)</td>
<td>IOP &lt; 21 mm Hg and/or lowered by 20% or more</td>
<td>70.6%/1 y with Ahmed implant</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Wilson et al.⁴</td>
<td>Trabeculectomy (64)</td>
<td>IOP reduction</td>
<td>68.1%/3 y with trabeculectomy</td>
<td>41.7%/y with Ahmed implant</td>
<td>73.53%/2 y with ECP</td>
</tr>
<tr>
<td>Gedde et al.⁵</td>
<td>Baerveldt implant (107)</td>
<td>IOP &lt; 21 mm Hg</td>
<td>84.9%/3 y with Baerveldt implant</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>De Jong et al.¹¹</td>
<td>Ex-PRESS (39)</td>
<td>IOP &lt; 21 mm Hg</td>
<td>66.2%/3 y with Ex-PRESS</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Gianoli et al.¹²</td>
<td>Phacoemulsification with deep sclerectomy (30)</td>
<td>IOP &lt; 21 mm Hg</td>
<td>59%/1 y with phacoemulsification with deep sclerectomy</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>D’Eliseo et al.¹³</td>
<td>Deep sclerectomy (21)</td>
<td>IOP &lt; 20 mm Hg</td>
<td>61.9%/1 y with deep sclerectomy</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Cillino et al.¹⁴</td>
<td>Deep sclerectomy (17)</td>
<td>IOP &lt; 20 mm Hg</td>
<td>52.9%/1 y with deep sclerectomy</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Russo et al.¹⁵</td>
<td>Deep sclerectomy (21)</td>
<td>IOP &lt; 20 mm Hg</td>
<td>52.6%/1 y with deep sclerectomy</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Cillino et al.¹⁶</td>
<td>Deep sclerectomy (19)</td>
<td>IOP &lt; 20 mm Hg</td>
<td>55.5%/1 y with deep sclerectomy</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Jonescu-Cuypers et al.¹⁷</td>
<td>Viscocanalostomy (10)</td>
<td>IOP &lt; 20 mm Hg</td>
<td>50%/1 y with viscocanalostomy</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>O’Brart et al.¹⁸</td>
<td>Trabeculectomy (25)</td>
<td>IOP &lt; 20 mm Hg</td>
<td>70.5%/2 y with Ahmed implant</td>
<td>Not available</td>
<td>Not available</td>
</tr>
</tbody>
</table>
Glaucma Valve implant to trabeculectomy, and Gedde et al.6 compared the Baerveldt glaucoma implant to trabeculectomy with mitomycin C. Wilson et al. reported that the 41- to 52-month success rates were similar between eyes with an Ahmed implant (69.8%) and those with trabeculectomy (68.1%) and that those with trabeculectomy had lower IOPs during the first postoperative year. Differences in visual field scores from the baseline were similar after surgery in the eyes with the Ahmed implant and the trabeculectomy (P = 0.16). Gedde et al. reported a similar mean IOP at 3 years’ follow-up in the two groups (13.3 ± 6.8 mm Hg for trabeculectomy and 13.0 ± 4.9 mm Hg for Baerveldt), but a greater probability of failure (IOP >21 mm Hg and/or lowered <20%) during the 3-year follow-up for eyes with a trabeculectomy (30.7%) versus those with a Baerveldt implant (15.1%; P = 0.01). There were more cases of endophthalmitis in eyes with a trabeculectomy than in those with a Baerveldt implant. Visual function after the interventions was not reported.

The Ex-PRESS shunt was developed to shunt fluid from inside the eye to under the conjunctiva. Because there was a tendency for the shunt to erode through the conjunctiva, surgeons started placing the Ex-PRESS shunt under a partial-thickness scleral flap as a modification of trabeculectomy.7–9 In a randomized clinical trial by de Jong10 comparing the Ex-PRESS shunt with trabeculectomy, 80 eyes with open-angle glaucoma were randomly assigned to receive either Ex-PRESS implantation under a scleral flap or trabeculectomy. Complete success was defined as IOP >4 and ≤18 mm Hg without the use of glaucoma medications. At year 3, 66.7% of eyes with the Ex-PRESS were complete successes versus 41.0% of eyes with trabeculectomy (P = 0.02). At year 1, 12.8% of eyes with the Ex-PRESS versus 35.9% of eyes with trabeculectomy were being treated with glaucoma medications. At year 5, there was less of a difference in the percentage of eyes with medications (41% with the Ex-PRESS and 53.9% with trabeculectomy).11 Visual function before and after surgery or across study groups was not reported.

**Internal Filtration**

Nonpenetrating surgeries, developed at approximately the same time as the trabeculectomy but not widely used until recently,12–24 have become more popular in the past two decades. Canal-based procedures, which restore filtration through Schlemm’s canal, are designed to keep the normal anatomy instead of removing it and to be conjunctival bleb free, which should reduce the risk of long-term endophthalmitis and ocular hypotony. Both deep sclerectomy12–16 and viscocanalostomy17–23 have been compared to trabeculectomy in several randomized controlled clinical trials (Table 1). Although eyes that undergo trabeculectomy have been reported to be more likely to have complete success more often than those that undergo deep sclerectomy or viscocanalostomy, complications have been reported less frequently with deep sclerectomy and viscocanalostomy.12–25 Canaloplasty is designed to reestablish circumferential flow through Schlemm’s canal, through which the aqueous in the eye usually drains. A microcatheter is threaded through the canal, viscoelastic is used to dilate it, and a polypropylene suture is used to maintain its patency and exert tension on the trabecular meshwork. A Descemet’s window is made in the scleral bed so that aqueous can flow more easily into the canal. The only randomized trial with canaloplasty compared the dimensions of the polyprolene suture, either 6-0 or 10-0.24 With complete success defined as IOP ≤21 mm Hg without medications, 51% of eyes with 6-0 suture had complete success at 12 months; 76.9% of eyes with 10-0 suture had complete success. No randomized controlled clinical trials comparing canaloplasty with trabeculectomy or drainage devices have been reported.
Besides restoring aqueous flow around the canal, another approach to internal filtration is to improve the access of aqueous to Schlemm’s canal. The Trabectome (Neomedix Corp., Tustin, CA) involves ab interno microcautery that bypasses the trabecular meshwork and inner wall of Schlemm’s canal. In a prospective, randomized, open-label, multicenter trial of 240 eyes undergoing cataract surgery that were randomized to receive an iStent or not, 72% of eyes with the iStent had an unmedicated IOP of 21 mm Hg or less versus 50% of eyes without the iStent.25 Another new device that bypasses the trabecular meshwork and improves aqueous access to Schlemm’s canal is the iStent (Glaucos Corp., Laguna Hills, CA), a microsnorkel that is inserted into Schlemm’s canal. In a prospective, randomized, open-label, multicenter trial of 240 eyes undergoing cataract surgery that were randomized to receive an iStent or not, 72% of eyes with the iStent had an unmedicated IOP of 21 mm Hg or less versus 50% of eyes without the iStent.25 Although cataract surgery with the iStent appears to be associated with a greater success rate at 1 year than cataract surgery alone, which by itself is capable of reducing IOP, the eyes with the iStent and cataract extraction had on average an IOP only 1 mm Hg lower at 12 months than did the eyes with cataract extraction only.

**Summary**

A PubMed search performed on April 17, 2012, with the search term “glaucoma surgery” retrieved 16,712 references. Of those, 540 were randomized controlled clinical trials published in English and performed in humans aged 19 years or older. Randomized controlled clinical trials of the most recent surgical innovations that do not solely modify wound healing were reviewed herein (Table 1). Because of the limited number of randomized clinical trials of glaucoma surgical procedures and the lack of standardization in the definition of success, recommendations regarding which procedure is better for certain patients are difficult to make.

**References**


