The Evolution in Glaucoma Surgery – Latest Advances in Filtration Surgery

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Abstract

In recent years, an increased understanding of intraocular pressure (IOP) has facilitated advances in surgical techniques in the treatment of glaucoma. Although trabeculectomy has been the gold standard of glaucoma surgery for over four decades, new devices have recently been introduced, including the EX-PRESS™ glaucoma filtration device (GFDS). An important requirement of any surgical or medical procedure to lower IOP is effectiveness over a 24-hour period, since IOP is at its highest at night. Recent data have demonstrated that the EX-PRESS™ GFD can achieve a similar reduction in IOP to that achieved by trabeculectomy, but with a significantly reduced rate of complications. Following the successful learning of a number of surgical techniques, most of which are currently mastered by the skilled trabeculectomy surgeon, implantation of the EX-PRESS™ GFD is no more challenging than a traditional trabeculectomy and provides rapid post-operative recovery. Since cost considerations prohibit the use of the EX-PRESS™ GFD in all cases of glaucoma surgery, patient selection is important. It must be stressed, however, that use of the EX-PRESS™ GFD results in reduced indirect costs as a result of its better predictability, shorter operative time and reduced short-term post-operative complications.

Keywords

EX-PRESS™ glaucoma filtration device, glaucoma, filtration surgery, intraocular pressure, trabeculectomy

Introduction

Moderator: Jeffrey Liebmann

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Professor Liebmann introduced the symposium with a brief discussion of existing surgical options for glaucoma. Trabeculectomy has been the gold standard of glaucoma surgery since 1970. However, we are entering a new era in which new devices are becoming available, including the EX-PRESS™ glaucoma filtration device (GFDS). The presentations, during the symposium, focused on new developments in filtration surgery in the treatment of glaucoma.
Professor Weinreb commenced by stating that elevated pressure in the eye is the most important risk factor for glaucoma, and lowering of intraocular pressure (IOP) is currently the only effective treatment. The devices that have been recently developed in glaucoma surgery all focus on lowering IOP. If these devices are to be successful in the long term, it will become increasingly important to understand the mechanisms that cause changes in IOP and also demonstrate that they provide IOP-lowering over the 24-hour day.

Research has demonstrated that IOP follows a circadian rhythm; it is highest at night in healthy individuals and those with glaucoma. This may have considerable significance for clinical practice: for two-thirds of the time, peak IOP occurs outside office hours and as a result ophthalmologists do not capture the maximum IOP in routine measurements. It therefore may be important to use treatments that lower IOP throughout the 24-hour period. Furthermore, ocular perfusion pressure, which is the difference between blood pressure and IOP, has been associated with glaucoma. At night, when the patient is in a supine position, IOP is at its highest. Conversely, blood pressure is often at its lowest at night, therefore ocular perfusion pressure is lowest at night.

The circadian rhythm of IOP is largely driven by the secretion of aqueous humour, its highest rate of secretion, 3 microlitre/minute (µL/min), is in the morning between 06:00 and 12:00, which represents one-third of the day’s total. Paradoxically, this rate of secretion is lowest at night, which raises the question: why does IOP peak during the night? In part, this can be explained by the fact that episcleral venous pressure which influences IOP is increased in a supine position. The rhythmic regulation of IOP is also controlled by sympathetic innervation of the eye that is susceptible to the position of the body.

The medical management of glaucoma is still the first choice in most cases. Recent attention has focused on two drug classes: prostaglandins (PGs) – which increase the drainage of aqueous humour through the uveoscleral outflow pathway – and carbonic anhydrase inhibitors – which inhibit the production of aqueous humour. Published data have demonstrated that PGs lower IOP both during the day and at night. Furthermore, the effect is sustained following a month of treatment with the PG travoprost; IOP-lowering persisted after the omission of 1–2 doses. Between 41 to 63 hours after the last dose, diurnal IOP reduction was attenuated, but nocturnal IOP reduction was sustained (Figure 1). By contrast, although the alpha-2 agonist brimonidine significantly lowered IOP during the day, it did not significantly lower IOP at night. In patients already receiving PGs, the addition of the carbonic anhydrase inhibitor brinzolamide significantly reduced IOP over a 24-hour period.

Monitoring IOP to detect changes in IOP over a 24-hour period can provide invaluable information for glaucoma management. There are three approaches:

- self-tonometry;
- temporary continuous measurement; and
- permanent continuous measurement.

Self-tonometry is a well-established technique but it is difficult for most patients to perform. The use of a sensing contact lens allows minimally invasive IOP monitoring over prolonged periods by measurement of changes in corneal curvature correlated to variations in IOP.

Further information about the importance of IOP in glaucoma is given in the World Glaucoma Association Consensus Series. During the next few years, emerging surgical techniques will create a range of different therapy permutations allowing personalised treatment to become a reality in glaucoma.
Introduction of an Advanced Glaucoma Filtration Device

Tarek Shaarawy

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Professor Shaarawy began by emphasising that the efficacy profiles of surgical techniques have not been exceeded by medical therapy. Until recently, surgical options have been limited and include trabeculectomy, using devices such as the EX-PRESS™ GFD, implanted tubes and non-penetrating glaucoma surgery (NPGS). Trabeculectomy remains the benchmark to which to compare the numerous emerging procedures. However, it is associated with complications: a recent study found severe loss of central vision in 6% of patients with advanced glaucoma after a trabeculectomy. Other complications included hypotony, maculopathy, cataracts and endophthalmitis.19

The EX-PRESS™ GFD is a small device, less than 3 mm in length. It reduces IOP in a similar way to trabeculectomy, by diverting and filtering aqueous humour from the anterior chamber to the sub-scleral space and under the conjunctiva. There are important differences, however. The EX-PRESS™ GFD is inserted under the scleral flap with no tissue removal. The outflow is controlled through the lumen of the GFD according to a fluid mechanics equation. Two internal lumen sizes are available: 50 and 200 μm. In order to achieve successful implantation of the GFD, a good, well-trained technique is required. The following are recommended:

- a scleral flap larger than the GFD footplate;
- planning where stitches are required prior to implantation (to minimise subsequent fibrosis); and
- a sclerotomy 26 g needle with careful positioning and manipulation.

The EX-PRESS™ injector is ingeniously simple, allowing easy release of the GFD without any complex manoeuvres (Figure 2).

Long-term data demonstrating the safety and efficacy of the EX-PRESS™ GFD are available.11,12 A recent study found that the pressure reduction achieved with the EX-PRESS™ GFD is similar to that of a trabeculectomy, but the complication rates are significantly reduced. Visual recovery was significantly quicker in the EX-PRESS™ group and was achieved one week after implantation (Figure 3).13

The safety aspects of glaucoma surgery cannot be emphasised enough, and trabeculectomy is currently underutilised because of the potential for serious complications. The advantages of the EX-PRESS™ GFD include standardised flow, potentially better predictability, shorter operative time and a short learning curve. There is no need for peripheral iridectomy and there are fewer short-term post-operative complications. In terms of disadvantages, a study suggested that glaucoma valve implants may cause endothelial cell loss,10 and further investigation is required to evaluate the impact of implanting the EX-PRESS™ GFD on the endothelial cells. The other disadvantage is that of cost. The use of EX-PRESS™ GFD increases the direct cost of surgery but the indirect cost may be lower as a result of reduced complications and fewer post-operative office visits.

In summary, there is a need for a surgical technique that is more predictable than the current options. Implantation of the EX-PRESS™ GFD offers a safer, more standardised alternative.

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Figure 2: Injector for the EX-PRESS™ Glaucoma Filtration Device

Figure 3: Visual Recovery One Week After Implantation in a Retrospective, Consecutive Case-control Series

**Legend:**
- **EX-PRESS™ glaucoma filtration device (n=35)**
- **Trabeculectomy (n=35)**
- **Time at which visual acuity returned to baseline**

**Note:**
- MAIR = minimum angle of resolution
- **Source:** Good, Kahnok, 2011.13

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Improving Predictability in Filtration Surgery

Carlo E Traverso

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Professor Traverso began by discussing the continuing popularity of filtration surgery, which is very effective in lowering IOP in the majority of appropriate patients. However, ocular morbidity during this procedure is not a rare event and is potentially sight-threatening. The development of the EX-PRESS™ GFD and associated implantation technique has led experts to claim that ‘the 50-year reign of trabeculectomy as gold-standard glaucoma procedure is at an end’. The EX-PRESS™ GFD is advantageous because it is made of inert stainless steel that is fully biocompatible and safe for magnetic resonance imaging (MRI).7–11

The procedure for implantation of the EX-PRESS™ GFD does not require a significant change to the skill set of an accomplished trabeculectomy surgeon, although a number of techniques make EX-PRESS™ GFD implantation less variable. The EX-PRESS™ GFD does not shrink or bend. Occlusion of the tube from the outside is very rare if positioned properly and can be effectively treated with the neodymium-doped yttrium aluminium garnet (Nd:YAG) laser.12

The surgical procedure begins with a peritomy. Next, a 33–50 % depth scleral flap is dissected. Antimetabolites are applied, then a pre-incision is created using a 25–27 g needle, with the insertion point at the lower end of the blue-grey zone. It is important to always enter parallel to the iris. The EX-PRESS™ GFD is then inserted using the insertion device. The scleral flap is then sutured into position and the outflow checked, tiring the suture tension as necessary. Finally, the conjunctiva is sutured and checked for watertightness.

Since cost considerations prohibit the use of the EX-PRESS™ GFD in all cases of glaucoma surgery, it is necessary to select the most appropriate patients. It is particularly recommended in combined procedure with phacoemulsification or penetrating keratoplasty (PKP). It is also indicated in eyes of patients with delicate anatomy (for example, those that have been previously operated on) and also for monocular patients or younger patients.

The efficacy of the implantation technique was first reported in 200910 and considerable data supporting its use have since been published.11,12,13,14

In a prospective, non-randomised study (37 eyes of 35 patients), the implantation of the EX-PRESS™ GFD achieved reduction in IOP equivalent to that of trabeculectomy at last follow-up (minimum 12 months, maximum 24 months), with IOP reaching the targets of <18 mmHg and <15 mmHg at last follow-up in 78.4 and 70.3 % of participants, respectively.15 In another study, the IOP was significantly lowered in the first two weeks following implantation and was sustained over three years.16

In the first prospective, randomised study, the outcome measures of IOP <18 mmHg or <15 mmHg were achieved in a significantly higher percentage of the EX-PRESS™ group compared with those receiving trabeculectomy, although the trabeculectomy outcomes were worse than average.12 A retrospective comparative study concluded that the two techniques had similar IOP-lowering efficacy although the EX-PRESS™ group had a significantly lower rate of early post-operative hypotony and choroidal effusion.17 In a recently published randomised controlled trial that compared trabeculectomy and implantation of the EX-PRESS™ GFD in fellow eyes of the same patient, complete success rates (IOP <18 mm Hg without medications) were significantly higher with the EX-PRESS™ GFD compared with trabeculectomy (p=0.0024). Furthermore, in a study including 30 eyes of 15 patients followed for a mean duration of 23.6 months, post-operative complications were more frequent after trabeculectomy compared with the EX-PRESS™ GFD (33 versus 20 %) (Figure 4).18

A review of clinical experience concluded that implantation of the EX-PRESS™ GFD results in consistent creation of a uniform opening into the anterior chamber with less damage to surrounding tissue compared with standard tissue punch techniques. It appears to be associated with less post-operative inflammation, less hypotony and quicker visual recovery.19 It must be stressed, however, that implantation under a scleral flap is not a substitute for good technique. Erosions may still occur if the GFD is not implanted properly. Future developments in device design may lead to more appealing devices and improved IOP control compared with standard trabeculectomy techniques.
In conclusion, the EX-PRESS™ GFD is a useful addition to the treatment armamentarium for glaucoma, achieving a more predictable and durable reduction in IOP than pre-existing surgical techniques with minimal side effects reported so far.

**Surgical Pearls in Filtration Surgery with the New Glaucoma Filtration Device**

Marco Nardi

Professor Nardi commenced by likening the procedure of trabeculectomy to drilling a hole in the eye and hoping. Most complications arise in the immediate post-operative period and are due to hypotony. However, in employing the EX-PRESS™ GFD, the appropriate patients must be selected. All cases of open angle glaucoma are suitable for implantation but in cases of narrow angle glaucoma it is important to consider whether a combined procedure is appropriate.

If the surgeon performs only a trabeculectomy, cataract may be induced and in narrow angle there is the danger of malignant glaucoma. Moreover, future surgery for cataract may make the trabeculectomy fail. On the other hand, if a combined procedure is performed, cataract extraction will open the angle and allow the EX-PRESS™ GFD to be implanted. It is also necessary to evaluate if the anterior conjunctiva is receptive for filtration, if not, a tube or a conjunctival advancement may be indicated.

Prevention of complications associated with implantation of the EX-PRESS™ GFD involves several factors:

- preparation of scleral flaps and use of antimetabolites;
- the use of releasable sutures;
- correct insertion of the EX-PRESS™ GFD; and
- conjunctival closure.

Professor Nardi prefers scleral tunnel incisions, not only because the flap is more regular, but also because with this technique it is possible to insert a sponge soaked with mitomycin C in the tunnel; this limits the scarring that may encapsulate the head of the device. Pre-placed releasable sutures allow control of the filtration, which results in no post-operative hypotony, reducing the number and importance of complications and allowing increased filtration after release.

Implantation of the EX-PRESS™ GFD is a closed chamber technique (Figure 5). Correct positioning of the GFD is essential; it should be placed in as posterior a position as possible and parallel to the iris. Closing the sutures involves the formation of a sliding knot and pulling on the suture (Figure 6). Correct conjunctiva closure is also necessary and an intra-operative Seidel test is recommended at the end of the procedure—any leakage promotes scarring and flat blebs in the early post-operative period. The timing of releasable suture removal is crucial; too early results in over filtration and hypotony, too late leads to scarring and failure. Removal of sutures is easy and can be performed with forceps, usually between the second and third week after surgery.
In conclusion, the EX-PRESS™ GFD is less variable, more efficient and safer than trabeculotomy. It yields more consistent, repeatable results, faster patient recovery and is becoming the first choice in glaucoma surgery for many doctors.