Patients are naturally apprehensive about undergoing ocular surgery. The anxiety is greater when the surgery carries a high risk of complications and ocular morbidity, as is the case with trabeculectomy and tube shunt surgeries. The introduction of micro-invasive glaucoma surgery (MIGS) has created a new paradigm for the role of surgery in the disease’s management. The safety profile of MIGS is superior compared with traditional filtration surgery, and the many complications of filters such as bleb leaks, bleb infections, and hypotony are not concerns.\(^1\)\(^-\)\(^3\)

Surgical intervention used to be considered a last resort for patients who were on maximal medical therapy. Patients’ adherence to their glaucoma medication regimens is an ongoing concern for eye care providers. The more complex the glaucoma dosing regimen is, the more likely a patient is to be noncompliant.\(^4\) With the availability of MIGS approaches, surgery is no longer a final consideration for patients with elevated intraocular pressure (IOP) and visual field progression despite maximal medical treatment.

MIGS techniques are typically used in the management of early to moderate glaucoma. Evidence has shown that cataract surgery alone reduces IOP in patients with mild to moderate glaucoma.\(^5\)\(^-\)\(^8\) The pairing of cataract surgery with a MIGS procedure can provide a powerful reduction in IOP along with a favorable safety profile. Herein I review the MIGS devices available to patients and some that are in the development pipeline. MIGS devices can be generally classified as using either an ab interno or ab externo approach.

**AB INTERNO MIGS DEVICES**

**iStent (Glaukos Corporation)**

In 2012, the iStent was approved by the US Food and Drug Administration (FDA) for use in conjunction with cataract surgery. This stent was designed to serve as a bypass through the trabecular meshwork to facilitate physiologic outflow of aqueous and thus to lower IOP.\(^1\) The stent is inserted through the same clear corneal incision used during cataract surgery. Implantation of the iStent at the same time as cataract surgery has a better safety profile than traditional filtration surgeries in combination with cataract surgery.\(^1\) Adding the device to cataract surgery produced no compromise in the visual outcomes or safety of the cataract surgery procedure.\(^1\) Studies have shown additional IOP reduction beyond cataract surgery alone and decrease in medication usage when this stent is added to the cataract procedure.\(^1\)\(^,\)\(^9\)

Two related devices, the iStent inject and iStent supra (both from Glaukos) are in FDA clinical trials. The iStent inject is a second-generation version of the iStent. Surgeons can implant more than one of these devices into Schlemm canal. The device resembles a rivet or punctal plug, with the end inserted into Schlemm’s canal and the head in the anterior chamber allowing aqueous fluid to pass through the lumen in the middle of the device.

The iStent supra is designed to release aqueous through the uveoscleral outflow pathway. This stent is a 4-mm tube made of polyethersulfone and titanium and is designed to be placed in the suprachoroidal space. Few data have been published about this device. One small study reported IOP reduction of at least 20% and discontinuation of at least one glaucoma medication in 98% of study participants.\(^10\)

**CyPass (Transcend Medical)**

The CyPass stent is a small (6.2 mm length, 0.3 mm diameter), fenestrated, polyamide device that is inserted with a guide wire in a supraciliary location. It is designed to improve uveoscleral outflow by creating a controlled cyclodialysis. This device targets the suprachoroidal space, which has a larger absorptive capacity, allowing increased outflow and IOP lowering compared with the trabecular pathway. Like many other MIGS devices, it is placed through a clear corneal incision and can be used in combination with cataract surgery. One recent study concluded the CyPass stent precluded the need for more invasive glaucoma surgery in > 80% of patients at 1 year.\(^11\) Baseline mean IOP in this same...
study was 24.5 in phakic and pseudophakic patients with open-angle glaucoma. With implantation of one stent, mean IOP at 1 year was 16.4 mm Hg, a 34.7% reduction.\textsuperscript{11} Other studies have shown IOP reductions of 35% to 40% when baseline IOP is around 21 mm Hg and discontinuation of one glaucoma medication when the CyPass is combined with cataract surgery.\textsuperscript{12} It appears to have an outstanding patient safety profile, and postoperative recovery is similar to that of cataract surgery alone.

**Hydrostent (Ivanits)**

The Hydrus, now being evaluated in trials for FDA approval, is about the size of an eyelash and is placed inside Schlemm canal through a clear corneal incision during cataract surgery. It is an 8-mm long crescent-shaped open structure, curved to match the shape of Schlemm’s canal. It increases outflow by dilating Schlemm canal over 3 clock hours, allowing aqueous to bypass the trabecular meshwork and provide direct aqueous access to multiple collector channels. In recently published data 80% of patients undergoing cataract surgery plus receiving a Hydrus microstent had a 20% reduction in washed out diurnal IOP compared to 46% of patients undergoing cataract surgery alone at 2 years.\textsuperscript{13} The number of patients using no hypertensive medications was significantly higher at 2 years in the Hydrus plus cataract surgery group (73%) compared to the cataract surgery alone group (38%).\textsuperscript{13}

**Trabectome (NeoMedix)**

The Trabectome is an FDA-approved handheld instrument that uses microelectrocautery to ablate a 60° to 120° strip of the trabecular meshwork and the inner wall of Schlemm canal. Irrigation and aspiration is simultaneously performed to remove ablated tissue. The ablation allows aqueous to have direct access to the outflow collector channels of Schlemm canal, thereby lowering IOP. The procedure is performed through a clear corneal incision and has been described as a trabeculectomy ab interno. The Trabectome technique can be performed as a standalone glaucoma procedure or combined with cataract surgery. In a clinical trial, a 31% reduction in IOP and 28% reduction in postoperative medications at 1 year was demonstrated with the technique’s use as a standalone procedure.\textsuperscript{14} Other studies have demonstrated a 30% to 40% reduction in IOP with reduction of one to two medications, along with low incidence of vision-threatening complications.\textsuperscript{15–17} Disadvantages of the procedure include the possibility of postoperative IOP spikes and postoperative hyphema.

**Xen Gel Stent (AqueSys)**

The Xen implant uses an ab interno subconjunctival approach to lowering IOP. The Xen is a soft, flexible gelatin implant about the diameter of a human hair. It shunts fluid from the anterior chamber to the subconjunctival space. The implant procedure can be done alone or as part of cataract surgery. This stent is different from others in that it bypasses the natural drainage pathway and can produce the lower IOPs that typically are achieved only with a trabeculectomy or tube shunt. Its advantages over a trabeculectomy or tube shunt include a reduced chance of hypotony, an operative time of 15 to 20 minutes to implant, and minimal postoperative management. The implant, on the end of an inserter, is advanced across the anterior chamber and placed into the subconjunctival space opposite the incision.

**AB EXTERNO MIGS DEVICES**

***Ex-Press Glaucoma Filtration Device (Alcon)***

The FDA-approved Ex-Press mini glaucoma shunt is a 0.4-mm \( \times \) 3-mm piece of stainless steel with a lumen of 50 \( \mu \)m or 200 \( \mu \)m that can be used in conjunction with trabeculectomy surgery to allow aqueous fluid into the subconjunctival space. The device is inserted into the anterior chamber under a scleral flap with no sclerectomy or iridectomy needed.\textsuperscript{18} The Ex-Press shunt produces uniform filtration to more precisely regulate IOP and provides a more predictable outcome than standard trabeculectomy. Recovery is more rapid and postoperative hypotony and its sequelae are less common compared with traditional trabeculectomy.\textsuperscript{19}

**iTrack250A (Ellex) for Canaloplasty**

The iTrack250A microcatheter is inserted into Schlemm canal under a scleral flap. The microcatheter allows 360° catheterization and viscodilation of the collector channels. It also allows placement of a tensioning suture, which can act like a stent to enlarge and hold open Schlemm canal. One study reported mean IOP reduction of roughly 8 mm Hg in patients with open-angle glaucoma at 3 years after undergoing canaloplasty or combined cataract-canaloplasty surgery.\textsuperscript{20} One disadvantage of canaloplasty is the risk of perforating Descemet membrane.

**Endoscope (Endo Optiks) for Endolaser Cyclophotocoagulation**

Endoscopy with a 23-gauge video endoscope enables visualization of structures that are not routinely accessible to standard viewing, such as the ciliary body and its processes. Endolaser cyclophotocoagulation (ECP) utilizes a 810-nm
diode laser to selectively and precisely ablate the pigmented ciliary epithelium to decrease aqueous production, thus lowering IOP.\textsuperscript{21} ECP treatment usually entails a 270° to 360° ablation of the ciliary processes at the time of cataract surgery. Risks, although low, include cystoid macular edema and hypotony. ECP is a useful procedure for glaucoma management that can be combined with phacoemulsification and has been shown to be comparable to other filtering procedures in the control of IOP with perhaps fewer complications.\textsuperscript{22,23}

**Solv Gold Shunt (Solv)**

The Solv Gold shunt, a 24-karat-gold supraciliary device that measures 5.2 mm long, 2.4 to 3.2 mm wide, and less than 0.1 mm thick, is being studied in an FDA clinical trial. It is designed to increase uveoscleral outflow. It is inserted through an external scleral incision with the anterior portion of the shunt lying in the anterior chamber, the body residing intrasclerally, and the posterior portion in the suprachoroidal space. The device contains nine channels through which aqueous humor drains from the anterior aspect to the posterior portion in the suprachoroidal space.

**CONCLUSION**

MIGS is being adopted by surgeons around the world for glaucoma management. The devices and procedures described above have reduced complication profiles compared with trabeculectomy and have a powerful ability to facilitate aqueous outflow to lower IOP.

Eye care providers would like to avoid the problems associated with full-thickness filtering procedures, such as hypotony, choroidal hemorrhage, and bleb complications. MIGS can help eye care providers on the front lines of treating glaucoma by slowing the progression of this leading cause of irreversible vision loss.

10. Junemann J. Twelve month outcomes following ab interno implantation of a suprachoroidal stent and postoperative administration of triamcinolone to treat open angle glaucoma. Paper presented at: European Society of Cataract and Refractive Surgeons Annual Meeting; October 5-9, 2013, Amsterdam, Netherlands.

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