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Market Intel: Micro-Invasive Glaucoma Implants Mark Hottest Growth Spot In Eye Surgery Products Market

by Marion Webb

The rising aging population and ever-increasing incidences of glaucoma and cataract are clearing a bright path for the ophthalmic surgical products market, which is expected to reach $9.4bn by 2021, a CAGR of 4.6% from 2016. *Meddevicetracker* expects that continued innovation in minimally invasive technologies and next-generation surgical systems, developed by giants like Alcon and smaller rivals, will address the need of hundreds of millions of people suffering from cataract and glaucoma, the two leading causes of blindness globally. In this feature, we'll take a closer look at the overall market and the key players in the individual segments of surgical systems, surgical instruments and IOLs. We'll take a deep dive into the smallest, yet fastest-growing MIGS devices segment and talk to surgeons about how they're transforming glaucoma management for their patients.

Cataracts, the leading cause of blindness, affect some 120 million people worldwide, but only an estimated 15% of people with cataracts are being treated with cataract removal surgery, which provides a huge window of opportunity for device makers to address this unmet need.

While some 20 million cataract surgeries of all types are performed each year worldwide, most procedures are done in developed nations. But even in developed nations, such as the US and Europe, only a certain percentage of people are being treated with today's sophisticated phacoemulsification systems or ultrasound "phaco" systems to remove cataracts and then replace it with an artificial intraocular lens (IOL); which is another hot area for device makers developing premium IOLs that address vision problems like astigmatism and potentially eliminates the need for prescription glasses. But with greater access to care and improved income, device makers will find potentially lucrative opportunities in emerging markets such as India, Asia and Latin

America, areas with strong demand due to underpenetration of next-generation surgical techniques and the dire need to prevent blindness in a large and growing population.

The incidence of glaucoma, the second-leading cause of blindness, is expected to rise to 76 million by 2020 and 112 million people by 2040 worldwide and disproportionally affects people in Asia and Africa due to a lack of diagnosis and care.

Early treatment for glaucoma is critical for preventing vision loss. The first line of treatment is typically eye drops, which has shown to cut the risk of developing glaucoma by about half, but these medications are also very costly, burdensome or hard to administer and have shown serious compliance issues. Surgical treatments to address the abnormally elevated intraocular pressure (IOP) caused by inadequate draining of the trabecular network, can involve laser surgery, conventional open surgery or a combination of the two. But emerging micro-invasive glaucoma surgery (MIGS) devices, which are tiny drainage implants, are seen as filling an important gap in the treatment of glaucoma, and while promising, require much more thorough investigation.

According to *Ivantis Inc.* which developed the *Hydrus Microstent* MIGS device, currently in US clinical trials, in the US alone about 20% of 3.7 million people undergoing cataract surgery have a concurrent diagnosis of glaucoma. The World Health Organization estimated that by 2020, 32 million cataract surgeries will be performed worldwide, and will include millions of people diagnosed with glaucoma. In the US, about 740,000 patients may be candidates for MIGS treatment, Ivantis said in a recent press release.

Global Market Overview

According to Meddevicetracker's "*Ophthalmic Surgical Product Market*," the global market for ophthalmic surgical products, which is divided into four segments – ophthalmic surgical systems, IOLs, MIGS devices and surgical instruments – is expected to rise from $7.5bn in 2016 to $9.4bn by 2021, a CAGR of 4.6% (*(Also see "Ophthalmology Surgeons, Companies Finding Solutions In Medtech*" - Medtech Insight, 18 Sep, 2015.)) *(see Fig. 1)*.

Fig. 1

Ophthalmic surgical product sales, combined market forecast ($m), 2016-21

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Totals may not sum due to rounding. This forecast assumes that no major adverse events or product recalls will negatively impact the market. IOLs = intraocular lenses; MIGS = micro-invasive glaucoma surgery

"Ophthalmic Surgical Product Market," Meddevicetracker

Ophthalmic surgical systems, which include diagnostic systems and laser/phaco energy-based surgical therapy systems, make up the largest segment, but is expected to see the slowest growth from $3bn in 2016 to $3.5bn in 2021, a CAGR of 3.2%. The same growth percentage is expected for the third-largest segment, surgical instruments, rising from $645m in 2016 to $754m by 2021 *(Also see "All Eyes On Ophthalmic Devices Market*" - Medtech Insight, 14 Jul, 2015.).

IOLs, the second-largest segment in the overall ophthalmic surgical market, is expected to see only modest growth from $3.7bn in 2016 to $4.5bn, a CAGR of 3.9%. However, despite single-digit growth, the surgical equipment, instruments and IOL segments are experiencing a moderate rebound compared to the past few years, reflecting pent-up demand and improving economies. The new emerging MIGS market will see the biggest growth from $121m in 2016 to $633m by 2021, a CAGR of 39.2%, driven in large part by addressing the shortcomings of glaucoma medications, which include non-compliance and side-effects, as well as those of laser or non-invasive surgical therapies (See Fig. 2).

Fig. 2

Ophthalmic surgical products market, estimated global share by supplier, 2016

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Notes: Others include: A.R.C. Laser GmbH, HOYA Surgical Optics, HumanOptics, LENSAR, Lenstec,

"Ophthalmic Surgical Product Market," Meddevicetracker

Alcon

Alcon Inc., a division of *Novartis AG*, dominated the global market in 2016 with a share of more than 47% based on sales of $3.5bn. Swiss giant Novartis has been realigning its operations in recent years to grow the troubled Alcon division. After underperforming in FY 2016 due to a lag in surgical segment revenues, the company finally posted revenue growth in Q2 2017; surgical revenue – including sales of IOLs – increased 3% that quarter, while vision care went up 2%, the first surge of growth in that division since 2014.

Novartis said it considered exiting the ophthalmology business, but after realigning its business to focus on eye care said it will decide whether to leave the eye care business or not by the end of 2018, at which point the company is expected to have entered the next growth phase. For now, it'll invest heavily in innovation.

Three of Alcon's largest competitors – *Johnson & Johnson Vision Care Inc.* (previously *Abbott Medical Optics Inc.*), Bausch + Lomb/Valeant Pharmaceuticals International Inc. and *Carl Zeiss Meditec AG* – contributed 44% of sales in 2016, amounting to more than $3bn in combined revenues with each player contributing 16%, 15% and 13% of sales respectively.

Bausch + Lomb

Valeant Pharmaceuticals, a $10bn pharmaceuticals and medical device firm, also offers a vast portfolio of eye care products, including contact lenses, IOLs and ophthalmic surgical devices through Bausch + Lomb, which it bought in 2013. In FY 2016, Bausch + Lomb reported $4.607bn in revenues, essentially flat over revenues of $4.603bn in 2015. The division doesn't report segmented surgical ophthalmic sales, but it is estimated that this portfolio contributes slightly more than $1bn annually in global sales, the majority of which comes from US sales.

Like its competitor, Alcon, Bausch + Lomb also banks on internal development of innovative products to grow its business. The company also expects to continue to benefit from the 2017 launch of ophthalmic surgical systems, including the *Stellaris Elite* and *Vitesse*.

Bausch + Lomb is developing a unique ophthalmic viscosurgical product that will protect the corneal endothelium during the phaco emulsification process of cataract surgery, while improving chamber maintenance and lubrication during IOL delivery.

Johnson & Johnson Vision

Johnson & Johnson entered the surgical ophthalmic devices space with the acquisition of Abbott Medical Optics (AMO) in February 2017 for more than $4.3bn, which strengthened its position in cataract surgical laser systems and laser refractive surgery. AMO is a leading manufacturer of IOLs.

In FY 2016, AMO had global sales of $1.2bn including products in three segments: cataract surgery, laser refractive surgery and consumer eye health.

Before AMO was bought, it launched several new products in FY 2015 including the *TECNIS Monofocal 1-Piece IOL* with the *TECNIS iTec Preloaded Delivery System* and the *Whitestar Signature PRO* phaco system for removing cataracts, both systems are sold in the US.

Carl Zeiss

After reorganizing its ophthalmic business in 2016 by combining the previous two strategic business units, ophthalmic systems and surgical ophthalmology, into one unit that encompasses the entire ophthalmic portfolio with the goal to optimize sales, increase market penetration and grow globally, the Carl Zeiss Meditec Group increased revenues for the fiscal year ended Sep. 30 in 2016 by nearly 5% to €1.1bn compared to the prior year. In FY2015/2016 ophthalmic devices

posted combined total revenues of €791.9m compared to €747.2m in the prior fiscal year, driven mostly by refractive laser systems.

In the refractive laser surgery market, parent company, Carl Zeiss Meditec AG benefitted from the FDA approval and launch of the minimally invasive *SMILE* procedure, in the US last September, which uses the *VisuMax* femtosecond laser for correcting myopia.

The company hopes to grow through innovation and plans to invest 10-11% in R&D annually.

Smaller Players

Several smaller competitors, including *Lumenis Ltd.*, *Glaukos Corp.*, *Ellex Medical Lasers Ltd.* and *Iridex Corp.*, contributed about 1% each with Glaukos contributing 1.5%. Other smaller manufacturers contributed roughly $330m, or 4.4% of total sales.

Though Glaukos' market share is small relative to the major companies, Meddevicetracker expects that the pioneer in the MIGS segment will be able to steadily increase its market share over the forecast period amid robust demand for its *iStent* technology, rising international sales and continued innovation leveraging its MIGS technologies.

In the last three years, Glaukos has seen steady growth. In FY 2016, it reported net sales of more than $114m, an increase of nearly 60% over $72m in sales in FY 2015. The company launched the first iStent in 2012, following US FDA approval and is steadily increasing its portfolio.

Glaukos, however, will be facing stiff competition from Alcon, which acquired a competing MIGS device called *CyPass Micro-Stent* from *Transcend Medical Inc.*

Emerging innovative players that are also now playing in this market segment include Ellex Medical Lasers and Ivantis, among others.

Australian-based Ellex Medical Lasers is a small, but rising competitor in the ophthalmic laser segment. In FY 2016, the company posted record high sales of nearly $73m, up $10.2m from FY 2015. The growth was driven in large part by rising global sales, especially in China, and a positive response to its ab-interno canaloplasty (*ABiC*) three-step MIGS procedure for reducing IOP in glaucoma patients, using its flagship *iTrack microcatheter*.

The iTrack is the only approved MIGS device in China, which is a key growth market, and Ellex has extension of approval until May 23 2022.

Another small device maker, Irvine, California-based Ivantis Inc. developed the *Hydrus Microstent* for reducing IOP in treating primary open-angle glaucoma. Mountain View, California-based Iridex Corp. is a $40m ophthalmic medical technology company specializing in

medical laser systems and associated instrumentation. Its core product, the *MicroPulse* laser technology, addresses glaucoma and retinal diseases. Israel-based Lumenis Ltd. markets the *SLT laser therapy* for treating open-angle glaucoma.

MIGS

MIGS devices are among the fastest-growing technologies for treating refractive mild to moderate glaucoma by reducing IOP and the progression of glaucoma. MIGS devices serve an unfulfilled niche given that current treatments -- eye drops that have shown poor compliance by patients and have side effects; laser therapy, which has shown high failure rates; and the gold standard of surgery, trabeculectomy – are no longer seen as valid options for the majority of patients, according to Meddevicetracker.

Since it involves placing a permanent implant into the eye, MIGS avoids the major issue plaguing glaucoma medication of patient non-compliance, providing a less-invasive, safe, and effective therapy to prevent permanent vision loss for refractory glaucoma patients.

While these technologies are new and therefore require more thorough clinical study evaluation, including comparison studies to evaluate which new competitive MIGS therapy is most efficacious, the MIGS segment is expected to see tremendous growth in the coming years.

Table 1

Selected new and emerging microinvasive glaucoma surgery implants and other technologies

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Source: Company websites

Glaukos

Currently, more than half a dozen companies are directly competing in the MIGS space, which was pioneered by the $100m Glaukos Corp., which, up until last year, was the only company with a US FDA-approved MIGS device (Also see "*Glaukos' Micro-Bypass Stents Work As First-Line Glaucoma Therapy*" - Medtech Insight, 26 Sep, 2016.) (see Video 1).

Video 1

Eyes Arizona MIGS iStent placed in the eye during cataract surgery for reducing intraocular pressure for glaucoma and cataracts

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Glaukos Corp.

The company launched the first-generation iStent in the US in mid-2012 and outside of the US, the next-generation MIGS systems *iStent inject* and *iStent supra* received the CE mark in 2010, and is now being sold in Australia, Canada, Germany, South Korea and Taiwan, among other countries.

James Murphy, a glaucoma specialist at the Eye Center of Southern Connecticut in New Haven, Connecticut said he's been performing MIGS procedures since the iStent came to market in 2012 and is also now using the newer Alcon CyPass Micro-Stent.

He said he uses the iStent predominantly in patients with mild glaucoma and the CyPass mainly in patients with moderate glaucoma, but also sometimes in patients with mild glaucoma.

"I sometimes offer endoscopic cyclophotocoagulation (ECP) in conjunction with iStent implantation as it can offer additional IOP-lowering potential as it reduced the eye's production of aqueous fluid whereas the iStent aims to increase aqueous outflow via Schlemm's canal – it's all about lower in's and higher out's," Murphy told *Medtech Insight*.

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Brian Chen, a glaucoma specialist from the Acuity Eye Group in Los Angeles, said he's been able to lower patients' dependence on eye drop medications as well as lower IOP when performing ICE procedures (iStent combined with cataract surgery and ECP) compared to doing cataract surgery alone in glaucoma patients who need cataract surgery.

"In mild to moderate glaucoma (patients) who are uncontrolled or even controlled, but have

problems with eye drops, I offer the ICE procedure," Chen told *Medtech Insight*. "When glaucoma patient also need cataract surgery, I can make the most of ICE."

The iStent is designed to reduce IOP in the eye and restore natural fluid outflow by the trabecular micro-bypass method, creating a permanent bypass between the front part of the eye and its natural drainage pathway through the primary blockage site of the trabecular network. It has shown to reduce patients' reliance on glaucoma medication, with the majority of iStent patients in the US pivotal trial remaining medication-free at 12-month follow-up.

The company is leveraging its iStent technology to develop a next-generation pipeline, which includes four new products: the iStent inject, the iStent supra, the *iDose* and the *iStent infinite*.

Murphy said he's excited about the iStent inject, which he expects will be easier to use than the iStent, and with that will open the door of use by comprehensive ophthalmologists.

"I think when iStent inject comes out, it will be a little easier for a comprehensive ophthalmologist to use these devices in combination with cataract surgery, so that'll maybe encourage more use of MIGS amongst comprehensive ophthalmologists with ease of use," he said. It's easier to use, if you're not familiar with angle surgery, he added.

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For the iStent inject, Glaukos has developed two versions that are currently being studied in clinical trials: one injector with preloaded stents is being tested to evaluate safety and efficacy in lowering IOP in patients in conjunction with cataract surgery and the other is being tested to assess efficacy as a standalone treatment for lowering IOP.

The iStent supra drains the suprachoroidal space. The iDose with a travoprost intraocular implant is a drug delivery system that is implanted in the eye in a microinvasive procedure to

continuously deliver medication for extended periods of time to lower IOP.

An international study of 30 subjects (including 27 who endured prior trabeculectomies) showed that three iStents implanted in a standalone procedure provided a 52% reduction in mean IOP to 13.7mmHg at 12-month follow-up. Additionally, over the same time period, patients achieved a 77% reduction in the mean number of topical medications, from 1.83 preoperatively to 0.43 postoperatively. The company is planning to submit an IDE filing with the FDA in Q4 2017 to conduct a one-year study of about 65 patients. Provided study results are successful, Glaukos will seek 510(K) clearance for the iStent infinite.

Preliminary results of a *three-year-long Phase II study* of 154 patients comparing two models of iDose delivery systems using different travoprost elution rates compared to topical timolol maleate ophthalmic solution (0.5%) showed an approximate 8mm Hg reduction rate in mean IOP in both models of the iDose Travoprost systems after nine months post-op. The safety profile was also favorable with no incidents of hyperemia. The company said it will review the results with the FDA in Q4 2017 and commence Phase III trials in early 2018.

Alcon/Novartis

While Glaukos is benefiting from substantial growth thus far, it will face strong competition in the next five years from startups but also from Alcon, which has a strong sales force and the marketing clout to bring products to health care providers.

Meddevicetracker expects that more of the innovative smaller players will be swallowed up by big ophthalmic surgical product makers firms as seen with Alcon's 2016 acquisition of the CyPass Micro-Stent from Transcend Medical or Allergan’s 2016 buyout of the XEN Gel Stent from AqueSys.

Alcon's CyPass Micro-Stent received FDA approval in August 2016 and available in the US; in the EU it was introduced in April 2017. The device is indicated for treating patients with mild to moderate primary open-angle glaucoma in conjunction with cataract surgery or as a standalone procedure in patients with primary open-angle glaucoma who have failed previous medical treatments.

Video 2

Cypass Microstent, Alcon

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Alcon

The CyPass Micro-Stent is the first MIGS device to leverage an entirely new outflow pathway for excess aqueous fluid in the eye - the supraciliary space, which is the space between the sclera, the white outer layer of the eyeball, and the ciliary body. Once implanted, it creates a permanent conduit between the anterior chamber of the eye and the suprachoroidal space to improve the eye's natural drainage pathway, according to Alcon (see Video 2).

The device was approved by the FDA based on the COMPASS study, the largest MIGS trial to date, Alcon said.

The multicenter, controlled pivotal *COMPASS trial* of 505 patients, who were randomized to receive either phaco and CyPass Micro-Stent implantation (n=374) or phaco alone (n=131), showed at two-year follow-up that about 73% of eyes treated with the CyPass Micro-Stent achieved a ⩾20% reduction in IOP, compared to only 58% of eyes treated with phaco alone. Additionally, about 61% of eyes treated with the CyPass Micro-Stent achieved the target IOP (an unmedicated diurnal IOP between 6mmHg and 18mmHg) versus only 43.5% with cataract surgery alone, according to the study's lead investigator, Steven Vold. The CyPass Micro-Stent has been clinically proven to be 32% more effective in lowering IOP than cataract surgery alone, the author wrote.

Murphy said in his experience the CyPass can function similarly to an iStent.

"It just gives a little bit additional reduction to intraocular pressure or gives you IOP that is almost the same as traditional glaucoma procedures," he said. He said that he may also use the CyPass in patients with mild glaucoma and very elevated intraocular pressure.

"I find that you can get a greater reduction in IOP with the CyPass versus the iStent," he noted.

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According to Murphy, some glaucoma specialists have also seen that CyPass may offer a greater reduction in IOP in patients that are near-sighted, but patients that are far-sighted can have a slight myopic shift when CyPass procedures are performed in conjunction with cataract surgery,

which is undesirable.

Allergan

Allergan Inc. paved its way into the MIGS device market with the acquisition of *AqueSys's XEN Gel Stent*, which received US FDA approval in November 2016 for the surgical treatment of refractory glaucoma. The device has been commercially available in the US since early 2017 and received the CE mark in 2013. It is also available in Canada, Switzerland, and Turkey; more than 10,500 implants have been distributed worldwide.

The system, which includes both the XEN Gel Stent and preloaded disposable *XEN Injector*, is implanted via the ab-interno approach. The miniature gel stent is implanted via a small corneal incision, and effectively reduces IOP by creating a new drainage channel with a permanent implant that becomes flexible.

Chen said essentially the Xen Gel Stent is an ab-interno trabeculectomy. But he said he would prefer using the XEN Gel Stent over performing traditional trabeculectomy with his advanced glaucoma patients. To date, XEN Gel Stent is not reimbursed, which he said, is the biggest issue for him. He's also waiting for more clinical data.

The company claims that its device has a competitive advantage, because the XEN Gel Stent drains to the subconjunctival space, and is the first procedure that creates a low-lying, ab-interno bleb in refractory glaucoma.

The XEN Gel Stent is indicated for managing refractory glaucoma where previous surgical treatment has failed, or in patients with primary open-angle glaucoma and pseudoexfoliative or pigmentary glaucoma with open angles who are unresponsive to maximum tolerated medical therapy.

The US FDA approval was based on the success of the *US pivotal trial*, in which XEN reduced IOP from a mean medicated baseline of 25.1mmHg (±3.7mmHg) to 15.9mmHg (±5.2mmHg) at 12-month follow-up (n=52) in 65 patients with refractory glaucoma. In the trial, the mean baseline number of IOP-lowering medications was 3.5 (±1.0) versus an average use of 1.7 (±1.5) medications at 12 months. In the primary analysis, nearly 80% of patients achieved a ⩾20% reduction in diurnal IOP on the same or fewer number of medications compared to baseline.

Ivantis

Irvine-based Ivantis touts its *Hydrus Microstent* as the world's first “intracanalicular scaffold” for treating primary open-angle glaucoma, which is currently limited to only three treatment

options: eye drops, laser therapy and surgery.

Hydrus is the only device that dilates and reconstructs the Schlemm's canal, the primary pathway where fluid exists in the eye. The device is implanted in a quick outpatient procedure via extremely small incisions used in cataract surgery. Unlike traditional surgical procedures to treat glaucoma, no additional incisions are required, resulting in a significantly less invasive approach, termed ab-interno, which is believed to result in fewer complications and faster healing than traditional glaucoma surgery.

Murphy said he's excited about the prospects of the Hydrus Microstent.

"Hydrus (Microstent) may just open up more real estate of Schlemm's canal compared to iStent, which may or may not translate to an increased reduction in intraocular pressure after implantation of the Hydrus (device)," he said. The device is currently being evaluated outside the US in both cataract surgery and standalone glaucoma surgery and Murphy said he's waiting for clinical trial results to better evaluate the device.

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Ivantis submitted Hydrus for FDA approval on October 31, and disclosed the headline results from its US HORIZON trial in conjunction with the American Academy of Ophthalmology (AAO) annual meeting in New Orleans, which took place from Nov. 11-14, 2017.

The HORIZON study enrolled 556 patients across 38 centers in nine countries and included patients with mild-to-moderate primary open-angle glaucoma who were randomized to receive cataract surgery and the Hydrus implant or had cataract surgery alone. The study's primary endpoint was reduction in mean diurnal IOP from baseline at 24 months following medication washout.

At a 24-months efficacy cross comparison study, 77% of cataract surgery patients who were also treated with Hydrus achieved a greater than 20% reduction in unmedicated IOP, which compares to 53% of iStent patients who also had cataract surgery in the Gen 1 investigational study.

After seeing the headline data, Wells Fargo's Larry Biegelsen wrote in his analysis on Nov. 13 that the efficacy data on HORIZON on the surface looks better than Glaukos' Gen 1 iStent investigational device exemption trial, "which is consistent with the anecdotal feedback from our physician checks though confounders (e.g. patient washout) and varying study designs make it somewhat difficult to cross compare between studies."

"Anecdotally, physicians with whom we've spoke perceive Hydrus to be more effective than iStent Gen 1 but harder to implant," Biegelsen wrote. "We would expect GKOS' second-generation device, iStent Inject, to close the efficacy gap with Hydrus." He added, however, that it is currently difficult to compare the two devices, because the Inject data he reviewed is in a stand-alone setting, without cataract surgery.

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He expects that Hydrus' device could be FDA approved in mid-2018, if not slightly earlier.

"Our assumption continues to be that Hydrus will be approved a few months ahead of iStent Inject," he wrote. He expects the Hydrus to capture 5% of the US MIGS market in 2018, assuming the company will market the device on its own.

Ivantis closed a $25m Series C financing in January 2017, led by new investor RA Capital Management, and included new investor Mérieux Développement. The company said it plans to use the funds for commercialization.

InnFocus

The *MicroShunt Glaucoma Drainage System*, developed by Miami, Florida-based *InnFocus Inc.*, is the first minimally invasive standalone procedure for treating mild, moderate and severe primary open-angle glaucoma, which potentially represents a core advantage over other MIGS technologies, because it does not require simultaneous cataract removal.

The device gained the CE mark in 2012 and has been implanted alone or in combination with cataract surgery in clinical trials outside the US in patients diagnosed with early- to late-stage glaucoma where it showed a mean post-operative IOP below 15mm Hg, representing a reduction of 50% in IOP after three years of follow-up.

The device is about the size of an eyelash and is made out of material that has been used for 15 years in drug-eluting coronary stents. It is in late-stage clinical trials in the US and Europe and is the world's only randomized trial comparing its safety and efficacy against trabeculectomy, the gold standard for lowering IOP.

iSTAR Medical

Belgium-based *iStar Medical SA*'s first-generation device is the *STARflo Glaucoma Implant*, made of iSTAR's material, developed at the University of Washington, Seattle, a micro-porous drainage system that increases the eye's natural uveoscleral outflow. It is implanted via an ab-externo surgical procedure derived from trabeculectomy, the most common glaucoma filtering surgery.

iSTAR is now leveraging its *STAR technology* through its next-generation product, the *MINIject*, a MIGS device designed to significantly reduce IOP by improving aqueous humor outflow from the anterior chamber to the suprachoroidal space. In April 2016, iStar Medical raised 10m Euros in a Series B financing, which will support further development and fund its European clinical study, geared to achieving the CE mark.

The company announced on Oct. 27, 2017 it completed enrollment of 25 patients with mild to moderate open-angle glaucoma for its international study to assess safety and performance of the device as measured by IOP reduction at six months.

Ellex Medical Lasers

Ellex Medical Lasers Ltd.'s *iTrack microcatheter*, which was FDA approved in 2013, is the only illuminated miniaturized microcatheter designed for performing MIGS that is used to viscodilate Schlemm's canal during the ab-interno canaloplasty (*ABiC*) procedure.

ABiC claims to be different from other MIGS procedures in that it preserves tissue, doesn't damage tissue and doesn't require a permanent implant in the eye. It also doesn't leave behind a shunt or stent. It also claims to be the only MIGS system to comprehensively open up all of the components of the eye's natural outflow system: the trabecular meshwork, Schlemm's canal, the Collector Channels, and distal outflow system.

According to the company, 228-eye 12-months case series data reported an average reduction in

mean IOP of 30% with a 50% reduction in medication burden. Ellex reported nearly 30% growth in revenues for the iTrack in FY 2016 with sales of more than $6m. Ellex acquired iTrack from *iScience Interventional Corp.* in 2013.

MIGS Pros And Cons

Murphy and Chen both agreed that at least in their experience, MIGS has shown very little risks for patients.

"I've never had to follow up post-op any more than I would just follow up a regular cataract patient," Chen said about performing ICE procedures. He said on occasion patients may have increased inflammation post-surgery or a little bleeding from the iStent procedure.

"The downside or risks of having a MIGS procedure performed are pretty small whereas the downside or surgical risks of a traditional surgical glaucoma procedure are pretty major," Murphy said.

> ***"I've never had to follow up post-op any more than I would just follow up a regular cataract patient." Brian Chen, glaucoma specialist, Acuity Eye Group in Los Angeles, commenting on performing ICE procedures.***

MIGS patients normally wouldn't be considered for traditional surgery. Murphy said he performs traditional surgery in patients that either have severe glaucoma and need a big reduction in intraocular pressure or in patients that have had MIGS procedures that failed.

"The greatest disadvantage is that sometimes they fail (MIGS)," Murphy said. "Sometimes you don't get a reduction in intraocular pressure. If you qualify failure as no additional reduction in intraocular pressure over what you'd expect for cataract surgery or even pre-operatively for an IOP, then it could be even up to 30 or 40%."

"I approach glaucoma in a step-wise fashion in which you offer the less invasive procedures first (MIGS), and if those don't leave you with an IOP you are happy with, one can consider the more invasive traditional glaucoma procedures," he said, adding "It is not so easy to go the other way."

"I think the MIGS procedures have filled a treatment gap between topical therapy and traditional

SLT, and the traditional glaucoma procedures that was lacking. It's a big leap to make from eye drops to trabeculectomy or glaucoma drainage implants, and MIGS has fulfilled a need in between these extremes over the last 15 years," Murphy said.

"I think the MIGS procedures have filled a treatment gap between topical therapy and traditional SLT, and the traditional glaucoma procedures that was lacking. It's a big leap to make from eye drops to trabeculectomy or glaucoma drainage implants, and MIGS has fulfilled a need in between these extremes over the last 15 years," Murphy said.

At the same time, current MIGS devices are far from perfect, according to glaucoma specialist who declined to be named.

"Devices that enable us to increase outflow with minimal intervention and get good enough drops in pressure are obviously going to be quite desirable, so the ideal device hasn't been made yet," the specialist said.