Minimally Invasive Glaucoma Surgery (MIGS)

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Introduction

Glaucoma is the leading cause of irreversible blindness worldwide. Trabeculectomy is still the "gold standard" in glaucoma surgery. However it is associated with significant morbidity such as hypotony and bleb related complications[1], This has warranted a quest for alternate safer procedures ensuring better IOP control and QoL (quality of life).[2,3] This has led to the advent of Minimally Invasive Glaucoma Surgeries (MIGS). These procedures aim at either overcoming the resistance at the juxtacanalicular meshwork, increasing uveoscleral outflow via suprachoroidal pathway or by creating a subconjunctival drainage pathway.[4]

MIGS procedures are usually indicated in eyes with primary open angle glaucoma and are generally performed in combination with cataract extraction as safer and less invasive means of reducing IOP

INDICATIONS	CONTRAINDICATIONS
Primary Open angle glaucoma	Primary and Secondary Angle Closure Glaucomas
Pigmentary glaucoma ,Pseudoexfoliation glaucoma and other secondary open angle glaucomas	Advanced Glaucomas
Mild to moderate disease	Previous Glaucoma surgery
Glaucoma with co existing cataract	Need for lower target IOP

Classification of MIGS

1. Procedures increasing trabecular outflow by bypassing the juxtacanalicular trabecular meshwork (TM)

- Trabectome
- Excimer Laser Trabeculotomy (ELT)
- iStent
- Hydrus
- Gonioscopy-assisted Transluminal Trabeculotomy (GATT)

2. Subconjunctival drainage pathway

- XEN Gel Stent

3. Procedures increasing uveoscleral outflow via suprachoroidal pathway

- CyPass Micro- Stent (withdrawn)

Trabectome

Trabectomeis US Food and Drug Administration (FDA) approved high frequency (550 kHz) bipolar electrocautery with a 19.5 gauge disposable hand piece with an insulated foot plate containing electrocautery, irrigation and aspiration functions. It ablates a strip of Trabecular Meshwork (TM) and inner wall of Schlemm's Canal (SC) without affecting the surrounding areas. It removes the area of greatest resistance to the aqueous outflow and reestablishes access to the eyes natural drainage system. Itcan be performed simultaneously with cataract surgery.[5] It is recommended to not use viscoelastic during procedure as it can produce optical blur or can interfere with electrocautery. About 90 – 120 degree area can be treated through a single incision under direct gonioscopic visualization. IOP spikes and hyphema are known complications. Various trials have shown significant IOP reduction with trabectome.[6,7] However multicentre systematic data is awaited

Excimer Laser Trabeculotomy (ELT)

ELT (Excimer Laser Trabeculotomy) is done using 308 nm Xenon Chloride pulsed excimer laser which delivers photoablative energy to create micro perforations in the TM and inner wall of Schlemm's Canal. Healing response can be minimized by avoiding trauma to the outer wall of SC which contains fibroblasts. The laser device either uses a gonioscopy lens to visualize the TM or comes with an endoscopic laser probe for direct visualization.[9-10] laser burns are placed over 90 degrees. Microperforations and reflux of blood is considered to be an end-point of treatment. No serious adverse effects have been recorded. As per recent studies ELT lowers IOP and reduces AGM simultaneously for up to 5 years. ELT combined with phacoemulsification is more effective than ELT alone. It is also documented to be more effective in eyes with higher baseline IOP.[8]

iStent

The iStent is the first ab internoimplant designed for the treatment of mild to moderate glaucoma. It bypasses the outflow resistance at the trabecular level by creating a direct communication between the anterior chamber and Schlemm's canal. The procedure can be done de-novo or simultaneously with cataract surgery.

Figure 1a : Design of an iStent Fig 1b: Picture showing the actual size of istent. Image courtesy – Arvind Neelkantham , Glaucoma Centre of Texas

iStent is a FDA approved heparin coated, non-ferromagnetic implant made of surgical grade titanium. It has a ridged, snorkel design with 3 retention arches on its outer surface for secure placement (Figure a). A second-generation model called the iStent inject (Figure 3) has been available and the inserter comes preloaded with two stents allowing the injection at the same time without exiting the eye. The device is injected into the Schlemm's canal under gonioscopic view (Fig 3). Transient IOP elevation , intra operative blood reflux from Schlemm's canal, Stent malposition and obstruction are some of the reported complications.[9] A recent meta – analysis noted that there was a significantly greater IOP reduction after the use of two first-generation stents compared to one, irrespective of phacoemulsification status. For the first generation stent, combined phaco-iStent provided a greater level of IOP reduction and reduction in the number of medication classes relative to phacoemulsification alone[10].

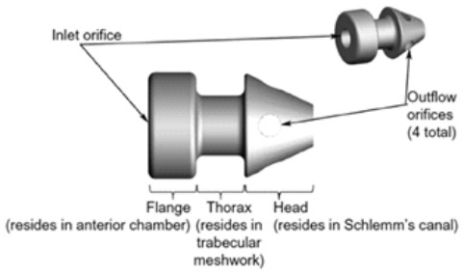

Figure 2 :Design of Istent inject

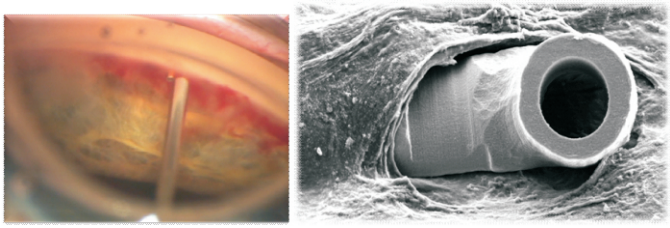

Figure 3 : iStent Snorkel sits parallel to the iris plane and iStent rails are seated against scleral wall of Schlemm's canal.Image Courtesy: Arvind Neelakanthan, Glaucoma Centre Of Texas

Schlemm's Canal Scaffold (Hydrus)

Hydrus Microstent (Ivantis, Inc, Irvine, CA, USA) is a crescent shaped implant made of ninitol. It bypasses the trabecular meshwork and dilates & supports the Schlemm's canal. The scaffold design helps to keep the collector channel accessible allowing greater flow of aqueous from the anterior chamber. The rationale behind dilating Schlemm's canal lies in the previous findings that elevated IOP actually causes the canal to collapse, leading to lasting changes in the TM and adjacent Schlemm's canal.[11] The device spans to three clock hours once inserted into Schlemm's canal under direct gonioscopic view. It dilates the canal by four to five times the natural width. Transient IOP spike, intra operative blood reflux from Schlemm's canal, Stent malposition and obstruction and focal peripheral anterior synechiae are some of the reported complications.

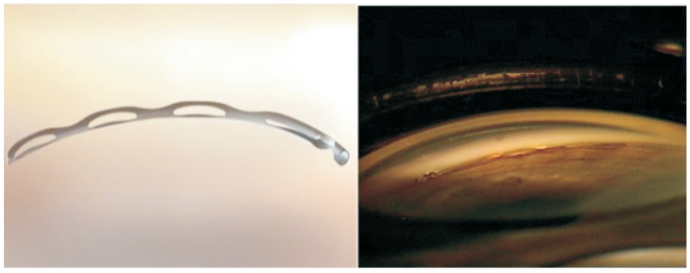

Figure 4a : Design of Hydrus implant and gonioscopic image showing hydrus implant insitu. Image courtesy –Brandon Lorry & Glen Burgess, Ivanti,Inc.

The FDA approval of hydrus was procured on the basis of 24 month results of the HORION trial where 556 mild to moderate glaucoma patients were randomized to 2 groups – cataract surgery with or without the microstent. More than 77% of patients with the implant exhibited a significant decline in unmedicated IOP, compared with 58% of the control group . No major adverse events were reported in the microstent group.[12]

Gonioscopy- assisted Transluminal Trabeculotomy (GATT)

GATT is a minimally invasive , conjunctiva sparing approach which cleaves the trabecular meshwork, thereby improving the normal conventional outflow pathway. A goniotomy is made in the nasal quadrant under gonioscopy lens. Schlemm's canal is cannulated 360 degrees using 5-0 prolene suture / microcatheter. Once the distal tip has circumnavigated the entire canal, it is retrieved and externalized. Gentle traction is applied to the externalized trailing end, creating a constricting loop, that gradually cleaves the entire TM and thus, creating a 360 degrees trabeculotomy ab interno. If cataract surgery is also planned, the GATT procedure is performed first followed by cataract surgery. Hyphaema and IOP spike can be seen post operatively. As per current data this technique is quite effective in primary and secondary open angle glaucomas and selected cases of anterior segmented dysgenesis in children.[13]

XEN Gel Stent/Aquesys

XEN gel stent (Aquesys) is FDA approved 6mm long , soft , permanent , non migrating device made of porcine gelatin cross linked with glutaraldehyde.It shunts aqueous from anterior chamber to subconjunctival space. When hydrated, it becomes compressible and tissue conforming. It comes in three different lumen sizes of 45, 65 , 140 micron. The implant comes with an injector, preloaded within a 27-gauge needle. As per Poiseulilles law of laminar flow , the length of the tube and inner diameter of the tube determine the rate of flow of aqueous. A preloaded injector is introduced in the anterior chamber through a clear cornea incision and is advanced till it reaches the opposite TM under direct gonioscopy (Figure 5a). The needle is inserted through the TM to create a scleral channel. It is further advanced till the bevel of the needle is seen in the subconjunctival space 3mm away from the limbus (Fig 5b) and the stent is released into the subconjunctival space (Fig 5c). A low lying ab interno bleb is formed immediately (Fig 5d) . Newer studies propose subconjunctival Mitomycin C use intra operatively or post operatively to reduce the subconjunctival fibrosis. It can also be combined with cataract surgery.

Figure 5 : XEN gel implant connecting the anterior chamber to the sub conjunctival space.Image Courtesy - Allergan

Figure 5a | Figure 5b | Figure 5c | Figure 5d

of implant has been reported. IOP spike in early postoperative period has been reported. As the procedure leads to bleb formation, subconjunctival fibrosis can occur requiring needling with antimetabolites. Few reports of internal ostium occlusion and corneal erosion have been noted.

The results of the AqueSys XEN 45 Glaucoma Implant in Refractory Glaucoma trial reported ≥ 25% reduction in mean IOP in 80.8% of eyes at 1 year follow up, but 32.3% eyes required needling with anti metabolites in the postoperative period.[14]

A recent study documented complete success in 80.4% and a qualified success in 97.5% of cases subjected to Xen stent implantation in conjunction with cataract surgery.[15] Xen implant has been noted to be effective in uveitic glaucoma.[16]

Suprachoridal Microstent (CyPass)

CyPass Micro-Stentwas devised as a flexible implant to be inserted into the supraciliary space from anterior chamber thus increasing the physiological uveo-scleral outflow. It got the FDA approval in 2016 for use in conjunction with cataract surgery in patients with mild to moderate open angle glaucoma based on results of 2yearCOMPASS study.A statistically significant reduction in intraocular pressure at two years post-surgery was noted in patients implanted with the CyPass Micro-Stent at the time of cataract surgery, as compared to subjects undergoing cataract surgery alone. At two years post-surgery, there was little difference in endothelial cell loss between the CyPass Micro-Stent and cataract surgery-only groups.

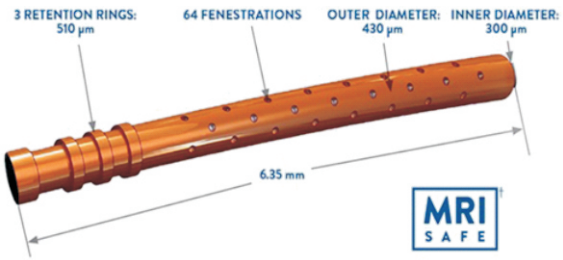

Figure 6: Cypass Microstent

The COMPASS-XT study was designed to collect safety data of the subjects who participated in the COMPASS study17for an additional three years, with analysis of the completed data set at five years post-surgery. At five years, the CyPass Micro-Stent group experienced statistically significant endothelial cell loss compared to the group who underwent cataract surgery alone. Endothelium cell loss was correlated with stent position within

the angle and with the number of retention rings noted on gonioscopy, particularly with two or more retention rings visible. Following these results , the stent was voluntarily withdrawn by the company in August 2018. Sufficient data on removal or trimming of stent is not available.

Conclusion

MIGSthus reduce the need for topical anti glaucoma medications in cases of mild to moderate glaucoma thereby minimizing patient adherence problems, increasing quality of life and potentially reducing lifetime costs of medications. 25Also the conjunctiva is spared for more invasive glaucoma surgeries in the future if required and reducing the bleb related complications.

However, the role of MIGS is reserved to mild to moderate glaucomas. These procedures alone are not adequate to achieve low target IOP needed for advance glaucomas

Other limitations of MIGS are lack of studies determining the longterm efficacy and safety of these procedures , lack of data pertaining to cost-effectiveness of the devicesand incomplete knowledge of ideal patient selection. In assessing current MIGS data, because most trials have included cataract surgery, it is important for clinicians to recognize the IOP-lowering ability of cataract surgery alone[17].

If supported longterm by studies , MIGS holds the potential to emerge as safer, minimally invasive and less morbid treatment option. Considering the ceaseless ongoing research and rapidly evolving technology, the field of glaucoma surgery might witness a drastic change in practice patterns in near future.

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