






Evolution of MIGS

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What is MIGS (microinvasive glaucoma surgery)

-  Enhance preexisting pathways for aqueous outflow avoiding major alterations in normal anatomy
-  ab interno approach, typically
-  IOP lowering is often less than traditional filtering surgery but should be at least 20%
-  The carry less risk of significant complications
-  Rapid recovery

clear cornea incision with direct visualization of tissue target and avoids use of the conjunctiva

Brief Timeline

- 1999: Glaukos produced first MIGS device- iStent prototype
- 2001: First human implant of the iStent
- 2005: FDA granted an IDE for US clinical trials
- 2012: FDA approval of iStent and first MIGS device approved in the US
- This was then followed by cypass in 2015 and Xen in 2016
- The term "MIGS" was coined by Ike Ahmed

MIGS Target

- Trabecular meshwork bypass via stent
 - iStent
 - Hydrus
- Trabecular meshwork bypass by tissue excision
 - Kahook Dual Blade
 - Trabectome
 - Gonioscopy assisted transluminal trabeculotomy (GATT)
 - OMNI
- Enhancing aqueous outflow through Schlemm's canal
 - OMNI
 - Tract canaloplasty
 - Streamline

MIGS Target

- Enhancing aqueous outflow through the suprachoroidal space
 - Cypass
- Shunting aqueous outflow into the subconjunctival space
 - Xen Gel Stent
 - PreserFlo Microshunt
- Reducing aqueous production by ciliary body ablation
 - Endocyclophotocoagulation (ECP)
 - Cyclophotocoagulation with G6 probe

Trabecular meshwork
Bypass via Stent

iStent

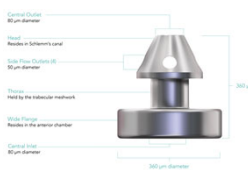
- Three versions
 - iStent (first generation)
 - L-Shaped
 - iStent inject (FDA approved 2016)
 - 2nd version called iStent W
 - iStent infinte (FDA approved 8/2/22)
 - FDA approved as standalone in refractory glaucoma
- Typically best for patients mild- moderate glaucoma

iStent First generation



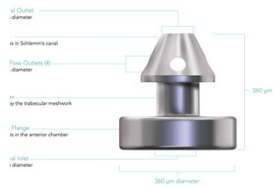
- 1 mm - made of heparin coated titanium
- Central lumen 120 microns
- Preloaded- one iStent
- Pivotal Study
 - Phaco (129) vs phaco/iStent (111)
 - Prospective, randomized trial
 - End point was IOP ≤ 21 at 12 months
 - 72% of iStent/phaco vs 50% phaco only reached end point
 - 66% of iStent/phaco vs 48% phaco only had IOP reduction of $\geq 20\%$
 - 68% of patients who received iStent at time of cataract surgery were medication free at 12 months

iStent infinte (W) generation



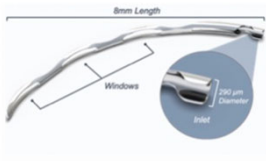
- 360 micron stent made of heparin coated titanium- pre loaded with two iStents
- Central lumen 80 microns
- iStent W is 360 microns vs 230
- Implanted 2-3 clock hours apart
- Pivotal Study:
 - Prospective, single- masked, multi center
 - 505 eyes total- 387 were phaco/iStent
 - 75.8% had $\geq 20\%$ reduction in IOP vs 61.9% in phaco alone
 - Mean IOP drop 7.4 mmHg vs 5.4 \pm 3.7 mmHg
 - 84% were med free at 23 month vs 67% in phaco only group

iStent Infinte



- iStent W expect now 3
- First FDA standalone
- Approved for refractory glaucoma
- Pivotal Study
 - Uncontrolled glaucoma with previous surgery or on maximum tolerated medical therapy
 - 76.1% had $\geq 20\%$ reduction without use of additional medication or secondary surgical procedures;
 - 53% had $\geq 30\%$
 - 21.2% had $\geq 40\%$

Hydrus



- 8 mm stent made of nitinol
- Spans 90 degrees of angle
 - Traverse the TM
 - Dilates the Schlemm canal
- Pivotal Study (Horizon Study)
 - 77.3% had $\geq 20\%$ reduction in IOP vs 57.8% in phaco alone
 - IOP drop in hydrus/phaco vs phaco only 7.6±4.1 mmHg vs 5.3±3.9 mmHG
 - Drop amount 1.7±0.9 to 0.3±0.8 drops in hydrus/phaco vs 0.7±0.9 in phaco only

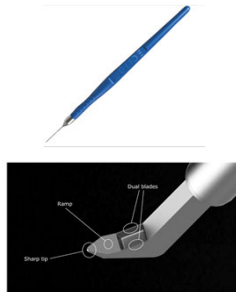
Compare Study

- Prospective Randomized trial comparing Hydrus and iStent 2nd generation
- Standalone treatment of OAG
- End point: IOP difference between groups and medications at 12 months
- Complete success: freedom from repeat glaucoma surgery, IOP ≤ 18 mmHg and no glaucoma medication
- 152 eyes from 152 patients (75 hydrus and 77 iStent)
 - Hydrus achieved an IOP ≤ 18 mmHg more often: 30.1% vs 9.3%
 - Hydrus group also eliminated more medication 1.6 meds vs 1.0
- Conclusion: hydrus resulted in a higher surgical success rate and fewer medications

Trabecular Meshwork Bypass by Tissue Excision

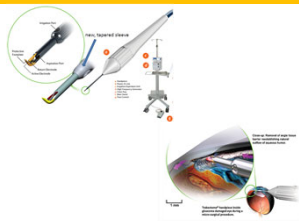
Kahook Dual Blade (Glide)

- 2 versions: Glide released October 2020
- Single use, disposable blade
- Glide: Rounded heel, tapered sides and smaller footplate
- Clinical study:
 - 52 eyes KBD with cataract
 - At 1 year mean IOP 16.8 ± 0.6 mmHg to 12.4 ± 0.3 mmHg
 - 57.7% had experienced a reduction $\geq 20\%$ IOP reduction
 - Drops decreased from 1.6 ± 0.2 to 0.8 ± 0.1



Trabectome

- Single use hand piece attached to a generator
 - Bipolar 550 kHz electrode
- Designed to disrupt or remove the inner wall of Schlemm canal and TM, opening canal and downstream collector channels
- Tip provides irrigation and aspiration and electrocautery in sequence
 - dissipate heat, remove debris and maintain anterior chamber
- Clinical outcome
 - Similar results with stand alone vs combined with phaco
 - 80 eyes of 69 pts with stand alone
 - IOP dropped from 26.6 ± 8.1 mmHg to 17.4 ± 3.4 mmHg at 6 months po
 - Drops decreased from 4.0 ± 1.4 to 2.3 ± 1.2



Gonioscopy- Assisted Transluminal Trabeculotomy (GATT)

- Ab interno trabeculotomy
- Can use either a 4-0 or 5-0 prolene suture or iTrack microcather
- Nasal goniotomy is performed then prolene suture or iTrack is advanced 360° in Schlemm's canal
 - If using a prolene suture, cautery is applied to suture tip to induce a mushroom head
- Proximal end is retracted while leading edge is grasped leading to shearing of TM 360
- Retrospective study of 198 eyes showed IOP reduction of 9 mmHg in POAG and 14 mmHg in secondary open angle at 2 years



OMNI



- Single use hand piece
- Can do canaloplasty or trabeculotomy
- Tip is used to pierce TM and suture within OMNI is advanced 180° when dialled back, canaloplasty is performed. Re advances and pulled out, trabeculotomy is performed
- Clinical study (with Trab360)
 - 81 eyes of 57 patients (all types of glaucoma)
 - stand alone
 - At 1 year, 41 eyes were available for analysis
 - The mean IOP reduction was 7.3±6.7 mmHg and 59% of eyes experienced a ≥20% reduction in IOP.
 - Drops decreased 1.7±1.3 from to 1.1±1.0

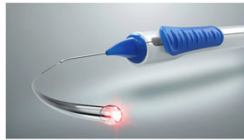
Enhancing Aqueous Outflow through Schlemm's Canal

OMNI (VISCO)

- 106 eyes of 71 patients
 - Group 1 IOP \geq 18 mmHg
 - Group 2 IOP < 18 mmHg
- Mild/Moderate glaucoma
- End point was IOP reduction and reduction in drops
- Group 1
 - 72 total (11 VISCO360 and 61 combo)
 - IOP reduced from 24.6 ± 7.1 mmHg to 14.6 ± 2.8 (average reduction 41%)
 - 87% achieved \geq 20% reduction in IOP
 - Drops reduced from 2.1 ± 1 to 0.2 ± 0.6
 - 85% required no medication
- Group 2
 - 34 total (33 combo, 1 VISCO360)
 - IOP reduced from 14.9 ± 1.8 mmHg to 13.6 ± 2.3 mmHg
 - Drops reduced from 1.8 ± 0.9 to 0.2 ± 0.6
 - 88% required no medication

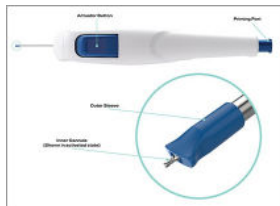
iTrack (Ab interno canaloplasty)

- 250 micro single use microcatheter with fiber optic light
- Schlemm's canal is cannulated 360 degrees and then vasodilation of the canal system and distal outflow system is performed upon withdrawal of the catheter.
- Can also do trabeculotomy like in GATT
- Clinical studies:
 - 75 eyes of 68 patients with POAG
 - 41 standalone
 - 34 with phaco
 - IOP drop: 20.4 ± 4.7 mmHg to 13.3 ± 1.9 mmHg at 12 months PO in both groups
 - 84.5% experiences an IOP reduction of \geq 20% from baseline
 - Drops decreased from 2.8 ± 0.9 drops to 1.1 ± 1.1
 - At 1 year- 40% were off all drops



Streamline Surgical System

- Single use and disposable
- Stainless steel cutting inner cannula with a polymer outer sleeve
- Depression of the actuator button creates 150 uM diameter goniotomy while delivering approximately 7uL of OVD for dilation of Schlemm's canal and collector channels
- Clinical trials:
 - Prospective, non randomized trial
 - 37 eyes from 37 patients- all Hispanic
 - IOP dropped from 23.2 ± 2.3 to 16.2 ± 2.2 mmHg at 12 months
 - 80% had \geq 20% reduction in IOP at 1 year
 - Drops decreased from 2.0 ± 0.8 to 0.8



Procedure	Time Point (Months)	Baseline IOP	Mean IOP Reduction (%)	% Achieving ≥20% IOP Reduction	Mean Medication Reduction (%)	% Medication-Free
STREAMLINE transconjunctival dilation of the canal of Schlemm (current study)	12	23.2 mmHg*	30.2%	80%	66.5%	55.4%
iStent (1st generation) ¹⁶	12	25.4 mmHg*	33.1%*	66%*	NA	80%
2 iStent (1st generation) ¹⁷	12	27.3 mmHg*	18.7%*	13.3%*	37.4%	24%
iStent inject (2nd generation) ¹⁸	24	24.8 mmHg*	31%*	78.5%*	75%	86.7%
Hydrus ¹⁹	12-24	26.3-27.5 mmHg*	29.8%-35.3*	39.7%-80*	60.4-73%	46.6-72.9%
Hydrus ²⁰	24	26.3 mmHg*	35.7%*	80%*	75%	72.9%
VivoCap ²¹⁻²²	12-18	22.0-24.6 mmHg	22-41%	87%	32-89%	32-96%
iTrack device ²³⁻²⁶	12-48	18.1-23.6 mmHg	26-40%	78.4%	39-97%	25-80%

Note: *Unmedicated.
Abbreviation: IOP, intraocular pressure.

Enhancing Aqueous Outflow Through the Suprachoroidal space

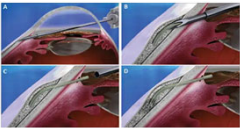

Cypass

- FDA recalled it from market in 2018 due to concern for endothelial cell loss found in COMPASS-XT trial
- Supraciliary device
- Stent was 6.35 mm long; inner diameter of 300 μm and outer 430 μm with 76 μm fenestrations along length of device
- It was a controlled cleft formation
- Proximal edge of stent had three retention rings

Shunting Aqueous Outflow into the Subconjunctival Space

Xen Gel Stent

- 6mm composed of porcine-derived gelatin cross linked with glutaraldehyde
- Inner lumen is 45 μ m in diameter and outer diameter is 150 μ m
- Loaded on single use handpiece and injected with 27 gauge needle
- ab interno technique is the xen introduced via a clear cornea incision, injector pierces from Tm and sclera (visualization helped with a gonio lens) into subconjunctival space.
 - MMC injected before or after
- Pivotal Study:
 - 65 patients with refractory glaucoma
 - Trial cut down conj and pre soaked MMC on bare sclera then did ab interno implantation
 - IOP decreased average of 9.1 mmHg
 - 75.5% of patient had \geq 20% reduction in IOP
 - Drops decreased from 3.5 drops at baseline to 1.

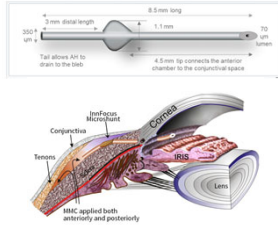



GPS Study: Xen vs Trab

- Prospective randomized, multicenter, noninferiority study
- Primary end points:
 - \geq 20% IOP reduction from baseline at the 12-month visit without any of the following:
 - Increase in topical IOP-lowering medication
 - Clinical hypotony (IOP \leq 6 mm Hg with vision reduction [\geq 2 lines] related to macular changes [macular folds], optic disc edema, and/or serous choroidal detachments)
 - Vision loss to counting fingers
 - Secondary surgical intervention (SSI)
- Secondary end points
 - mean IOP and medication count,
 - postoperative intervention rate
 - visual recovery
 - patient-reported outcomes (PROs)
- End results:
 - Xen was non inferior to trab: 62.1% vs 68.2% achieved primary end point
 - 62% were medication free in xen vs 71% in trab
 - Xen mean IOP was 14.4 mm Hg on 0.6 mean medications and trab mean IOP 11.8 mm Hg on 0.3 medications
 - Speedier visual recovery and less patient reported outcomes in xen

PreserFlo Microshunt

- Not FDA approved
- poly(styrene-block-isobutylene-block-styrene) or SIBS-biologically inert
- Length 8.5 mm, divided by a 3mm "fin" into distal (3 mm) and proximal (4.5 mm) segments. The external lumen is 350um and the internal lumen is 70um; a beveled tip at the proximal end.
- Clinical trial:
 - 2 year, prospective randomized trial
 - 395 microshunt vs 132 trabeculectomy
 - At 1 year, IOP decreased from 21.1±4.9 mmHg to 14.3±4.3 mmHg in MicroShunt versus 21.1±5.0 mmHg to 11.1 ±4.3 mmHg in trab
 - Probability of success was higher in patients randomized to trab- 72.7% vs 53.9%



Reducing Aqueous Production by Ciliary Body Ablation

Endocyclophotocoagulation (ECP)

- Endoscope probe attached to diode laser (810 nm) unit
 - Xenon light source
 - Helium-neon aiming beam
 - Fiber optic imaging
- Video monitor provides a view
- Laser setting is 0.2-0.25 watts → continuous
- Treatment is 200-360 degrees
- Treat until see ciliary body shrink and turn white
- Clinical study:
 - Non-randomized prospective study: 2 year f/u
 - ECP+CE vs CE in 160 patients with medically controlled glaucoma
 - IOP decreased from 18.1 ± 3.0 mmHg to 16.0 ± 3.5 mmHg in ECP/CE vs 18.1 ± 3.0 mmHg to 17.3 ± 3.2 mmHg in CE only
 - Drops: 1.5 ± 0.8 to 0.4 ± 0.7 vs 2.4 ± 1.0 to 2.0 ± 1.0

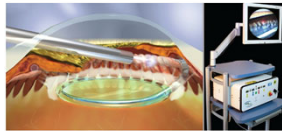


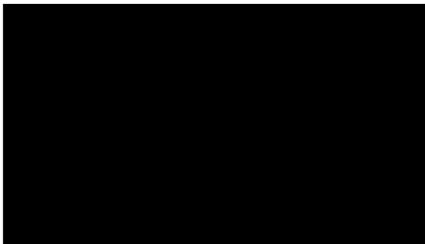
Figure 13. Endocyclophotocoagulation. ECP probe in ciliary sulcus space delivering energy to ciliary processes. Video screen of cryphotocoagulated ciliary processes after ECP procedure. Images used with permission.

Micropulse Transscleral Cyclophotocoagulation

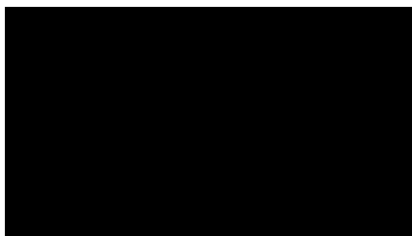
- Destroys the pigmented CB epithelium to decrease aqueous humor production
- In past, CPC reserved for refractory cases
 - High risk of uveitis, vision loss, chronic hypotony, choroidal detachment and phthisis bulbi and rarely sympathetic ophthalmia
- Micropulse is alternative, safer version → instead of continuous energy, it delivers a series of repetitive short pulses of energy alternating with rest periods between pulses
 - Rest period allows for "cooling" which minimizes collateral tissue damage
- 810 nm diode laser probed perpendicular to eye surface along limbus ("bunny ear" on the limbus)
 - Duty cycle is 31.3% → on 0.5 ms/off 1.1 ms per cycle
 - 2000-2500mW
 - Total treatment ranges from 100-360 seconds
 - Avoid 3 and 9 o'clock position → long posterior ciliary nerves



iStent inject



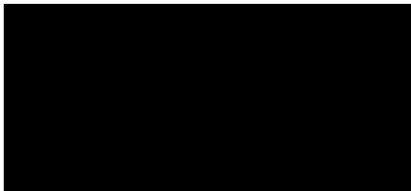
Hydrus



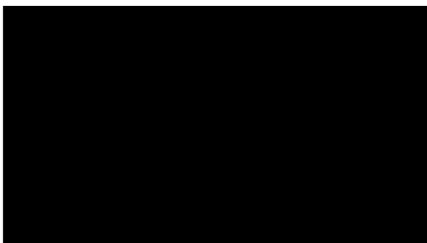
OMNI/Hydrus



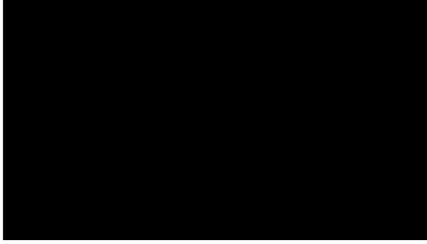
Old iTrack with GATT



iTrack



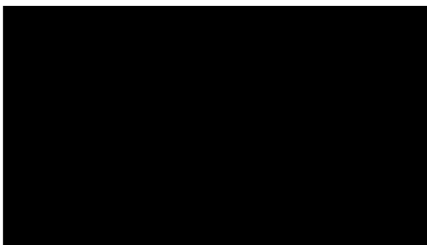
Streamline



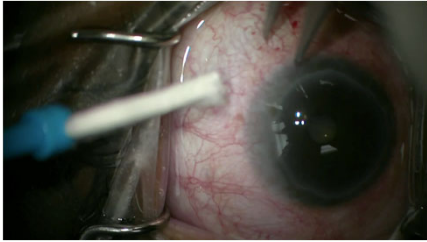
Trabectome



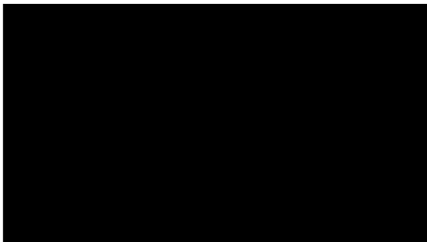
Xen Open Conjunctiva ab externo



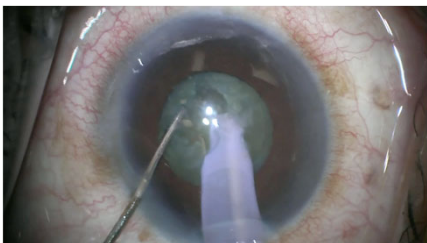
Xen ab interno



PreserFlo Microshunt



KBD with ECP



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