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REVIEW ARTICLE

Revolutionizing glaucoma treatment: The emergence and technique of mixed minimally invasive glaucoma surgery and compound MIGS

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Abstract

The landscape of glaucoma treatment has undergone a profound shift with the introduction of minimally invasive glaucoma surgery (MIGS), and within this paradigm, the emergence of mixed and compound MIGS has signaled a transformative departure from traditional approaches. Mixed MIGS intricately blends various MIGS techniques from the same anatomical location, harnessing their collective strengths to achieve optimal intraocular pressure management with minimized invasiveness, while the compound MIGS ingeniously harmonizes by handling various anatomical locations, namely, the inflow and outflow pathways, offering dual benefits of visual rehabilitation and simultaneous glaucoma control. These innovative procedures represent a confluence of surgical precision and therapeutic innovation, poised to reshape the landscape of glaucoma care by providing more effective, personalized, and comprehensive treatment options. This manuscript will serve as a valuable resource for ophthalmologists, researchers, and healthcare policymakers to navigate the evolving landscape of MIGS.

Full Text

Glaucoma, a leading cause of irreversible blindness, has long posed a challenge to ophthalmologists seeking effective and minimally invasive treatment options. Conventionally, glaucoma treatment has been associated with invasive surgical interventions that carry substantial risks, prolonged recovery periods, and excellent intraocular pressure (IOP) control. The emergence of minimally invasive glaucoma surgery (MIGS) has ushered in a revolutionary approach to glaucoma management, aiming to achieve effective IOP control with reduced risks and faster recovery.[1-4]

The Genesis of Mixed and Compound MIGS

MIGS techniques target the trabecular meshwork (TM) to enhance aqueous outflow by bypassing it with stents in the Schlemm's canal (SC) (iStent, iStent Inject, iStent Inject W, Hydrus), exploring the suprachoroidal space (CyPass micro-stent, iStent Supra, MINInject), subconjunctival filtration (MIGS PLUS, Xen implant, PreserFlo) or by excising the TM by Kahook Dual Blade (KDB) [Figure 1a], bent ab-interno needle goniectomy (BANG) [Figure 1b], gonioscopy-assisted transluminal trabeculotomy, trabectome and TRAB 360/OMNI.[5-9] In addition, techniques such as endoscopic

cyclophotocoagulation (ECP) and micropulse diode laser cyclophotocoagulation directly target the ciliary body to reduce aqueous production.[10]

Combining MIGS with cataract surgery is now a well-established and effective approach for managing both cataracts and glaucoma in a single surgical procedure. This offers benefits such as faster recovery, patient convenience, and potentially better long-term outcomes. As an innovative advancement, we are adding a feather to the cap of glaucoma management by introducing two new novel minimally invasive surgical techniques, one handling various anatomical sites by compound MIGS while mixed MIGS combines two techniques in one anatomical site for improved IOP control.

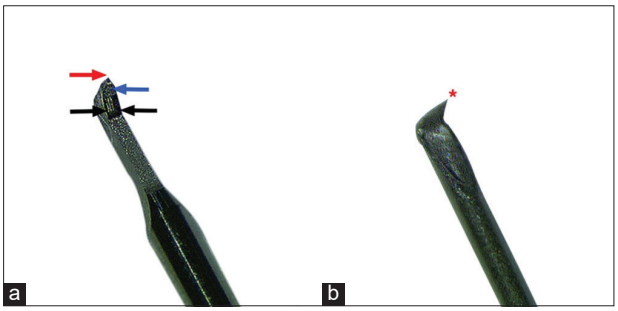


Figure 1: (a) Image showing parts of Kahook Dual Blade. It consists of a sharp tip (red arrow), a ramp (blue arrow), and dual blades for cutting (black arrow). (b) Image showing a bent 26-gauge needle (red asterisk) used to perform bent ab-interno needle goniectomy

Surgical Technique

Pre-operative evaluation

A comprehensive evaluation of the patient's glaucoma type, severity, and nasal angle evaluation using indirect gonioscopy, optical coherence tomography – retinal nerve fiber layer, and visual fields helps choose appropriate patients for combined and mixed MIGS procedures. A tailored treatment plan is crafted to harness the synergistic potential of mixed MIGS and compound MIGS.

Patient selection

Patients diagnosed with open-angle glaucoma and individuals with elevated IOP (ocular hypertension) may be considered suitable candidates for the performance of mixed MIGS. Compound MIGS is performed in patients with severe stages of open-angle glaucoma and refractory glaucoma. ECP can be performed even in a patient with severe corneal edema where the view to the anterior segment is obscured, which is an added advantage to control IOP.

Anesthesia and surgical preparation

Regional (sub-tenon block) or topical anesthesia is administered, and a sterile surgical field is established with a drape. A lid speculum maintains eyelid separation and provides clear access to the surgical site.

Step-by-step approach to mixed MIGS: A comprehensive fusion iStent with KDB

The amalgamation of iStent and KDB surgeries stands as a novel advancement in glaucoma management. The procedure involves placing a small 1mm titanium device into SC through the TM to improve aqueous outflow and lower the IOP. The KDB device is designed specifically for removing the TM. By ab-interno approach, a temporal clear corneal incision of at least 1.5 mm is made, and then the anterior chamber (AC) and angles are deepened using viscoelastic. It is essential to be careful about maintaining the appropriate eye inflation to prevent canal collapse and facilitate access. Similarly, inadequate inflation of the AC can result in corneal striae with gonioscopy.

The patient's head is inclined at an angle of approximately 30–45° away from the surgeon, while the microscope has been tilted 45° toward the surgeon. The procedure starts by adding viscoelastic beneath the direct gonioprism. The 1st generation iStent with the applicator was introduced through the corneal incision using the surgeon's dominant hand. Simultaneously, the gonioprism is positioned on the corneal surface using the non-dominant hand, ensuring a clear view of the nasal TM using the foot pedal adjustments. After clearly visualizing the nasal TM, the iStent is placed in the SC through the TM [Figure 2a]. A functioning trabecular outflow system is depicted by the blood flow within the collector channel. The 2nd generation iStent comes with an injector and two preloaded iStents, which are injected into the nasal angle adjacent to each other. Proper application of iStent is confirmed by paralimbal blanching between the region of insertion.

To further enhance the outflow of the aqueous humor, KDB goniectomy is performed along with iStent [Figure 2b]. The surgeon's dominant hand introduces the KDB blade through the corneal incision. Simultaneously, the gonioprism is positioned, ensuring a clear view of the nasal TM. The pointed end of the blade is skillfully directed through the TM and into the SC. Once the TM is pierced, the device's ramp is firmly positioned against the SC wall. This ramp, along with the dual parallel blades, produces paired parallel incisions in the TM. Subsequently, the device is rotated either clockwise or counterclockwise for approximately 3–5 clock hours, as per the surgeon's choice [Video Clip 1].

iStent with BANG

The fusion of iStent and BANG procedures epitomizes the progressive synergy within the realm of MIGS. The iStent is inserted into the SC, and the BANG procedure is executed to facilitate the outflow of aqueous humor. This procedure employs an ab-interno approach through a clear corneal incision in the temporal region, allowing for angle visualization using direct gonioscopy. A perpendicular approach to the TM is then utilized. To achieve this, a goniotome is fashioned by bending

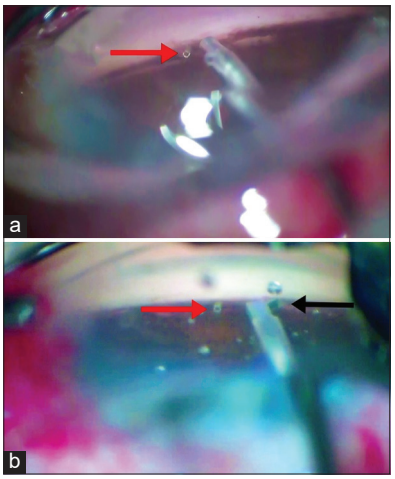


Figure 2: The surgical photograph showing (a) an implanted iStent (red arrow) and (b) a Kahook Dual Blade used to perform minimally invasive glaucoma surgery (black arrow) adjacent to the implanted iStent (red arrow)

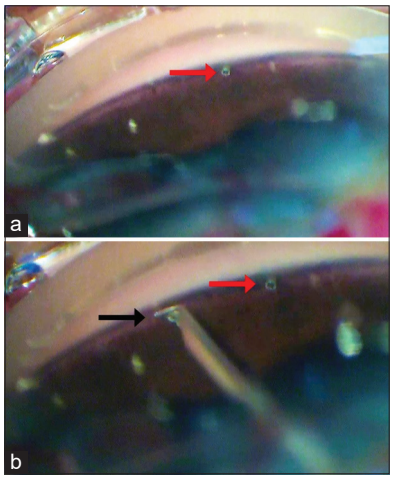


Figure 3: The surgical photograph showing (a) an implanted iStent (red arrow) and (b) bent ab-interno needle goniectomy being performed using a 26-gauge needle (black arrow) adjacent to the implanted iStent (red arrow)

the distal 1 mm of a sterile 26-gauge 5/8-inch hypodermic needle toward the bevel using a needle driver. After implanting the iStent, [Figure 3a], a gonioprism is positioned on the cornea to provide angle visualization. Subsequently, the bent needle is introduced through the corneal incision using the surgeon's dominant hand. Simultaneously, the gonioprism is positioned on the corneal surface using the non-dominant hand, ensuring a clear view of the nasal TM. The needle tip is carefully guided through the TM and into SC. Once the TM is punctured, the bent end of the device is secured against the SC wall. Then, the sharp tip is used to make an incision along the TM [Figure 3b], and it is then rotated either clockwise or counterclockwise for about 3–5 clock hours, depending on the surgeon's preference [Video Clip 2].

Step-by-step approach to compound MIGS: A harmonious duet

ECP introduces a novel dimension by utilizing endoscopic visualization and laser energy to target ciliary processes, effectively modulating aqueous production. As described above, any MIGS (BANG, KDB, etc.) can be performed to enhance the outflow along with ECP. Here, in this case, BANG is performed to reduce the IOP by enhancing the outflow [Figure 4a]. To reduce inflow, the procedure of ECP is undertaken [Video Clip 3]. ECP involves the use of an endoscopic probe connected to a laser unit, equipped with a diode laser (810 nm), a Xenon light source, a helium-neon aiming beam, and fiber optic imaging. The endoscopic view is displayed on a connected video monitor for the surgeon, who can control the laser using a foot pedal. The probe is available in various sizes (19, 20, or 23-gauge) and can be straight or curved. It is inserted into the AC through a clear corneal incision, typically located inferotemporally, to provide visualization of the ciliary body, ciliary processes, and angle

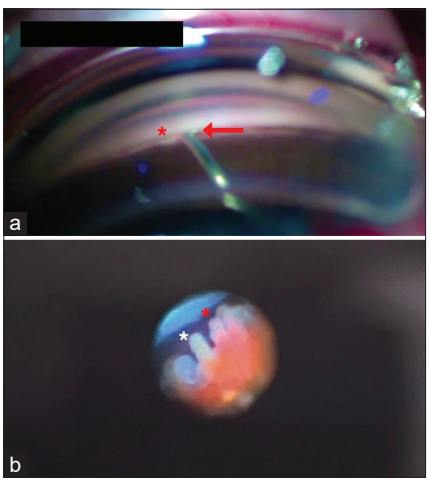
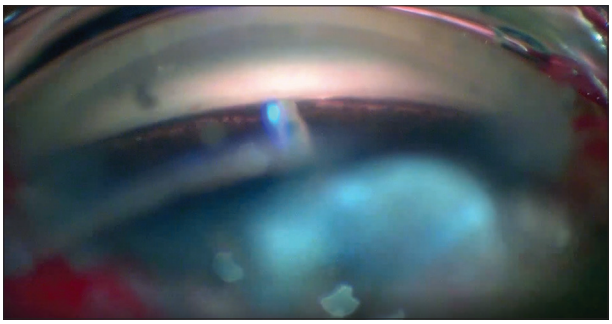
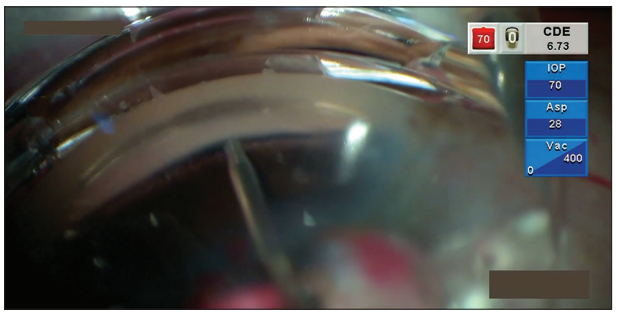


Figure 4: (a) The surgical photograph shows a de-roofed Schlemm's canal (red asterisk), following bent ab-interno needle goniectomy using a 26-gauge needle (red arrow). (b) Image displaying endoscopic cyclophotocoagulation, showcasing a blanched and photocoagulated ciliary process (white asterisk) and an untreated ciliary process (red asterisk)

structures. After anatomically identifying the ciliary process landmark, laser energy is used to achieve photocoagulation and necrosis [Figure 4b]. The laser is initially set at 0.2–0.25 watts with a continuous cycle, and the power is adjusted gradually to achieve both the blanching and contraction of the ciliary processes. The laser energy should be applied quadrant after quadrant, based on the surgeon's strategy. Observe for signs of adequate tissue blanching and coagulation. Treatment typically consists of 200°–360° of the circumference. Withdraw the endoscope and ensure the incisions are properly hydrated to achieve water-tight closure [Video Clip 4].



Video Clip 1: The video depicts the surgical steps of mixed minimally invasive glaucoma surgery – iStent and Kahook Dual Blade procedure
Video Clip 1: https://youtu.be/V_tgZmUuhhI



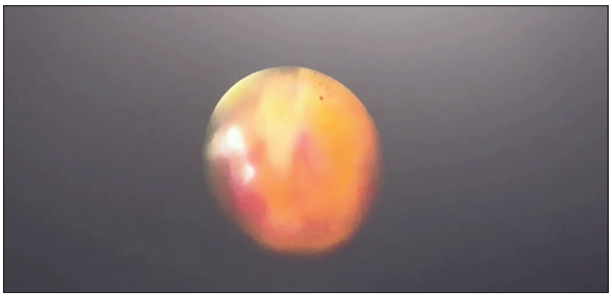
Video Clip 2: The video depicts the surgical steps of mixed minimally invasive glaucoma surgery – iStent and bent ab-interno needle goniectomy procedure
Video Clip 2: https://youtu.be/i_oiCbZN2BY

Wound closure and post-operative care

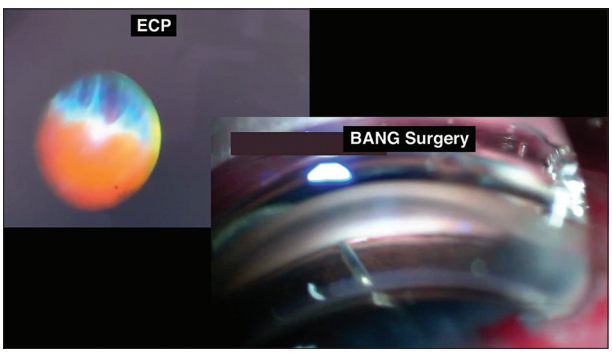
The viscoelastic substance in the AC is washed thoroughly, and the incisions are properly hydrated to achieve water-tight closure. The eye is carefully examined postoperatively. Tapering doses of steroid eye drops, topical antibiotic eye drops, and cycloplegics are given for patients undergoing mixed MIGS. In addition, oral acetazolamide and topical anti-glaucoma medication are prescribed to control IOP spikes in the immediate post-operative period for patients undergoing ECP. Comprehensive post-operative follow-up includes IOP assessment and medication adjustment to achieve desired pressure levels.

The significance of mixed MIGS and compound MIGS

Unlike standalone MIGS procedures, mixed MIGS and compound MIGS take a holistic approach to comprehensive glaucoma treatment. By synergizing different surgical techniques, they address multiple aspects of IOP regulation, optimizing patient outcomes. Mixed MIGS and compound MIGS have the potential to significantly reduce the need for glaucoma medications enhancing patients' lives and minimizing long-term side effects. Each case of glaucoma is unique, and the versatility of these novel approaches allows ophthalmologists to customize tailored treatment plans according to individual patient needs.



Video Clip 3: The video depicts the surgical steps of the endoscopic cyclophotocoagulation procedure
Video Clip 3: https://youtu.be/a-NAL1y7kVE



Video Clip 4: The video depicts the surgical steps of Compound minimally invasive glaucoma surgery – Bent ab-interno needle goniectomy and endoscopic cyclophotocoagulation procedure.
Video Clip 4: https://youtu.be/0UgLKlTsQn8

Conclusion

The emergence of mixed MIGS and compound MIGS has propelled glaucoma treatment into a new era, where precision and innovation harmonize to provide enhanced therapeutic options. These techniques represent the evolving landscape of glaucoma care, offering personalized, minimally invasive approaches that can reshape patient outcomes. As we navigate this intricate symphony of surgical intervention, mixed MIGS, and compound MIGS are transformative and pivotal in conquering glaucoma's challenges and creating a brighter future for global patients.

Declaration of Patient Consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. Patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of Interest

There are no conflicts of interest.

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