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Evolving Role of MIGS in the Combined Management of Cataract and Primary Open-Angle Glaucoma

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ABSTRACT

***Background*:** Primary open-angle glaucoma (POAG) is a leading cause of irreversible blindness globally. Its coexistence with cataract is common in the aging population. Minimally invasive glaucoma surgeries (MIGS) have emerged as safer, conjunctiva-sparing alternatives to traditional filtering procedures, offering modest IOP reduction with fewer complications and faster recovery. These procedures are especially appealing in cases with concurrent visually significant cataract, where they can be combined with phacoemulsification in a single session. This review aims to provide an updated, comparative overview of MIGS procedures applicable in coexisting cataract and POAG, focusing on the mechanisms of action, surgical techniques, and device-specific outcomes. It also highlights the role of combined surgeries, including BANG (Bent Ab Interno Needle Goniectomy), in current clinical practice and discusses the expanding indications of MIGS in different stages of glaucoma.

Conclusion:

MIGS procedures can be categorized by their target outflow pathway—trabecular, suprachoroidal, or subconjunctival—and by their surgical approach (ab interno vs ab externo). Devices such as the iStent®, Hydrus®, XEN® Gel Stent, and Kahook Dual Blade® represent diverse options that can be tailored to individual patient needs. BANG stands out as a cost-effective, practical solution with promising early outcomes, especially in resource-limited settings. While MIGS generally provide less IOP reduction than trabeculectomy, their safety and simplicity make them valuable for mild-to-moderate POAG and for patients undergoing cataract surgery. Long-term efficacy data and device-specific indications continue to evolve, reinforcing the need for individualized surgical planning based on glaucoma severity, angle anatomy, and the patient's systemic and ocular profile.

Keywords: Minimally Invasive Glaucoma Surgery, Cataract, POAG

INTRODUCTION

1. MIGS Overview – Definitions and Evolution

Minimally Invasive Glaucoma Surgery (MIGS) is a term that encompasses a variety of surgical procedures developed to reduce intraocular pressure (IOP) with a high safety profile, minimal trauma, and quick recovery. MIGS procedures are generally performed via an **ab interno** approach, sparing the conjunctiva, and preserving future options for more invasive surgeries like trabeculectomy or glaucoma drainage implants [1].

The concept of MIGS arose in response to the limitations of conventional glaucoma surgeries, which, although effective, are associated with significant risks such as hypotony, bleb-related infections, and long-term bleb failure. MIGS bridges the gap between conservative (medical/laser) treatments and full-thickness filtering surgeries by offering a **less invasive**, more controlled IOP-lowering effect [2,3].

MIGS procedures were initially indicated for **mild-to-moderate POAG**, often in combination with cataract surgery, particularly for patients with intolerance to medications or inadequate control on maximum tolerated medical therapy. Over time, with accumulating evidence and technological advancement, **the indications have expanded**, and certain MIGS techniques are now considered in select cases of advanced glaucoma or used as part of a multi-stage surgical strategy [4,5].

Key features of MIGS include:

- Minimal tissue disruption
- Conjunctival sparing
- Rapid visual recovery
- Favorable safety profile
- Compatibility with phacoemulsification

Today, MIGS represents a **diverse and growing category** that includes procedures targeting trabecular meshwork, Schlemm's canal, suprachoroidal space, and subconjunctival pathways. Understanding these different mechanisms is crucial for tailoring surgical interventions based on individual patient anatomy and glaucoma severity.

Classification of MIGS by Mechanism and Approach

Minimally Invasive Glaucoma Surgery (MIGS) procedures are best understood through their classification based on two critical dimensions: **mechanism of aqueous outflow** and **surgical approach**. This system helps guide surgeons in selecting the most appropriate technique based on glaucoma severity, angle anatomy, and previous ocular interventions.

A. Mechanism-Based Classification

1. **Trabecular Meshwork-Based (Conventional Pathway) MIGS** These procedures enhance physiological aqueous outflow by bypassing or removing the trabecular meshwork (TM) and accessing Schlemm's canal. They are effective primarily in eyes with open angles and intact collector channels. Examples include:
    - iStent®
    - Hydrus® Microstent
    - Kahook Dual Blade® (KDB)
    - Trabectome™
    - Bent Ab Interno Needle Goniectomy (BANG) [6,7]
2. **Suprachoroidal-Based (Uveoscleral Pathway) MIGS** These devices divert aqueous humor from the anterior chamber to the suprachoroidal space. Though this outflow is less pressure-dependent, safety concerns (especially endothelial cell loss) have limited their adoption. Examples include:
    - iStent Supra®
    - MINIject™
    - CyPass® (withdrawn from the market) [8,9]
3. **Subconjunctival MIGS** These procedures mimic traditional filtration surgery by creating a low-resistance pathway to the subconjunctival space, forming a bleb. Though more invasive than trabecular MIGS, they offer greater IOP reduction. Examples include:
    - XEN® Gel Stent
    - PRESERFLO® MicroShunt [10]
    -

B. Approach-Based Classification

1. **Ab Interno**: The procedure is done through a clear corneal incision using gonioscopic visualization. It preserves the conjunctiva and sclera, allowing for future filtering surgeries. Most trabecular and suprachoroidal MIGS fall into this category [6].

2. **Ab Externo**: These procedures involve external access through the conjunctiva or sclera. While more invasive, they provide better control over bleb formation in subconjunctival MIGS [10].

This classification highlights that **no single MIGS technique fits all patients**. Each procedure has strengths and limitations, and its utility depends on the target IOP, angle status, and whether combined cataract extraction is planned.

4. Indications, Contraindications, and Clinical Selection Criteria for MIGS

Minimally Invasive Glaucoma Surgery (MIGS) procedures have rapidly gained traction in the management of primary open-angle glaucoma (POAG), particularly in patients with coexisting cataract. Their primary indication is for individuals with **mild to moderate glaucoma** who have not achieved adequate IOP control despite maximum tolerated medical therapy or laser trabeculoplasty. MIGS is especially useful in patients undergoing cataract surgery, as the combined procedure offers the dual benefits of vision restoration and modest yet sustained IOP reduction [17,18].

In addition to inadequate IOP control, other common indications include poor medication compliance, intolerance to topical agents, or the presence of ocular surface disease exacerbated by chronic use of preserved eye drops. MIGS may also be considered for patients who have failed previous medical or laser therapies but are not ideal candidates for traditional filtering surgery due to systemic comorbidities or a high risk of complications. In such cases, MIGS offers a **less invasive, safer alternative** that can defer or even eliminate the need for trabeculectomy or drainage devices [19].

However, MIGS procedures are not suitable for all glaucoma patients. **Contraindications** include eyes with advanced glaucoma and significant visual field loss where a lower target IOP (<12 mmHg) is essential, as most MIGS techniques provide only a modest pressure reduction. Patients with **angle-closure glaucoma**, chronic uveitis, neovascular glaucoma, or extensive peripheral anterior synechiae (PAS) are also poor candidates, especially for trabecular-based MIGS, as angle accessibility and outflow integrity are essential for success [19,20].

Patient selection should be individualized and based on multiple factors, including glaucoma stage, target IOP, angle anatomy (evaluated via gonioscopy), medication burden, ocular comorbidities, and patient preference. For example, Schlemm's canal-based devices like iStent or KDB are ideal for eyes with open angles and mild disease, while subconjunctival MIGS (e.g., XEN Gel Stent) may be preferred in more advanced cases where a lower IOP is required but filtering surgery is contraindicated or has failed. Likewise, BANG may be chosen for its simplicity and cost-effectiveness in low-resource settings or when more expensive MIGS devices are unavailable [7,21].

Ultimately, a thorough understanding of the patient's disease profile, anatomical suitability, and tolerance for surgical risk is essential for selecting the most appropriate MIGS procedure. As new techniques and devices continue to emerge, and long-term data accumulate, the indications for MIGS are expected to expand, potentially altering traditional glaucoma surgical algorithms.

5. Advantages and Limitations of MIGS Compared to Conventional Surgery

Minimally Invasive Glaucoma Surgery (MIGS) has emerged as a valuable alternative to conventional glaucoma surgeries, such as trabeculectomy and glaucoma drainage devices (GDDs), particularly in patients with mild-to-moderate disease. One of the principal advantages of MIGS is its **favorable safety profile**. Because most MIGS procedures are performed via an ab interno approach and do not involve full-thickness scleral incisions or conjunctival dissection, the risk of serious complications like hypotony, bleb-related infections, or suprachoroidal hemorrhage is significantly reduced [22].

Another major advantage is the **preservation of conjunctival integrity**, which maintains the option for future filtering surgery if the MIGS procedure fails. Additionally, MIGS is associated with **faster visual recovery, shorter operative time, and reduced postoperative care burden**, making it an ideal choice for elderly or comorbid patients. When combined with phacoemulsification, MIGS offers a dual benefit of visual improvement and IOP reduction with minimal surgical trauma [23].

However, MIGS is not without limitations. The most important drawback is the **modest IOP-lowering effect**, especially when compared to trabeculectomy or tube shunt procedures. While traditional surgeries can lower IOP into the low teens or even single digits, most MIGS procedures result in a **20–30% reduction from baseline**, which may not suffice for patients with advanced disease or those with very high target pressure requirements [24].

Another challenge is the **variability in surgical outcomes**. Since many MIGS techniques depend on outflow through Schlemm's canal and collector channels, any anatomical variation, scarring, or distal outflow resistance can significantly affect their efficacy. Furthermore, **long-term data** for many MIGS devices are still evolving, with questions remaining about their durability, especially when used in isolation without cataract extraction [25].

Cost and accessibility also play a role. Some MIGS devices require proprietary instrumentation or are expensive, limiting their widespread adoption in low-resource settings. Techniques like BANG offer a solution to this barrier, providing similar outflow enhancement with inexpensive, readily available tools and no need for implants [7].

In summary, while MIGS offers a safer and less invasive option for glaucoma surgery with good outcomes in appropriately selected cases, it does not yet replace conventional procedures in patients requiring significant IOP reduction. Rather, MIGS serves as a **bridge**

between medical/laser therapy and incisional surgery, contributing to a more customized, staged approach to glaucoma management.

6. Clinical Outcomes, Complications, and Long-term Considerations

Clinical outcomes of MIGS procedures have generally been positive, especially when performed in combination with cataract surgery for patients with mild-to-moderate primary open-angle glaucoma (POAG). Studies have shown that MIGS can achieve a **20–30% reduction in intraocular pressure (IOP)**, often accompanied by a **reduction in the number of required glaucoma medications**. The efficacy is most pronounced in eyes with relatively well-preserved outflow anatomy and open anterior chamber angles [25].

While MIGS does not typically lower IOP to the same extent as trabeculectomy or tube shunt procedures, this trade-off is often acceptable given the **lower risk profile and faster recovery**. Clinical trials of devices such as the iStent inject®, Hydrus® Microstent, and Kahook Dual Blade® (KDB) have demonstrated sustained IOP control over 2–3 years, particularly when combined with phacoemulsification [11,12,13,25].

Complication rates with MIGS are generally low and transient. The most common intraoperative event is **microhyphema**, which occurs due to blood reflux from Schlemm's canal and typically resolves spontaneously within a few days. **Transient IOP spikes** may occur postoperatively due to retained viscoelastic or inflammation and are usually controlled with short-term medical therapy. Rarely, **device-related complications** such as stent malposition, obstruction, or migration may necessitate surgical revision [25].

Serious complications such as **endophthalmitis, choroidal hemorrhage, and hypotony** are significantly less frequent with MIGS than with traditional incisional surgeries. This safety profile makes MIGS especially valuable in patients with comorbidities or poor surgical tolerance [23,24,25].

However, **long-term durability** remains a concern. While 1–3-year outcomes are well documented, **five-year and beyond data are limited** for many devices. Late failure due to fibrosis or collapse of the treated outflow pathways may occur, particularly in procedures that rely on the trabecular meshwork and Schlemm's canal, where outflow resistance may return over time [25]. Additionally, in subconjunctival MIGS, bleb-related complications, though less frequent than with trabeculectomy, may still arise.

Ongoing research is focusing on identifying **predictors of long-term success**, such as the extent of collector channel accessibility, canal patency, and preoperative angle pigmentation. Moreover, **repeatability and retreatment strategies**—whether using the same or different MIGS approaches—are being explored to extend the lifespan of MIGS outcomes [25].

In summary, MIGS offers a clinically meaningful and safe IOP-lowering option for appropriate patients. While short-to-intermediate term data are encouraging, **ongoing monitoring and patient selection remain essential** to optimizing outcomes and guiding future MIGS innovations.

Conclusion

The landscape of glaucoma surgery has evolved significantly with the advent of **Minimally Invasive Glaucoma Surgery (MIGS)**, offering a spectrum of procedures designed to balance efficacy with safety. These techniques fill a critical gap between medical or laser therapy and more invasive filtering surgeries, particularly for patients with **mild-to-moderate primary open-angle glaucoma (POAG)** and coexisting cataract. By targeting specific anatomical outflow pathways with precision and minimal tissue disruption, MIGS procedures achieve a **modest but meaningful reduction in intraocular pressure (IOP)** while minimizing postoperative morbidity

Among the wide range of available MIGS procedures, **trabecular bypass stents** (e.g., iStent, Hydrus), **ab interno excisional techniques** (e.g., Kahook Dual Blade, BANG), and **subconjunctival or suprachoroidal drainage implants** (e.g., XEN Gel Stent, MINIject) each offer unique advantages that can be tailored to patient-specific needs. The growing clinical data suggest that, when appropriately selected, MIGS can reduce medication burden, stabilize disease progression, and improve patient satisfaction—especially when combined with phacoemulsification

Nevertheless, limitations persist. MIGS may be **insufficient for patients with advanced disease**, those needing low target IOPs, or in cases with compromised outflow anatomy. Moreover, concerns remain regarding **long-term efficacy**, fibrosis, device failure, and cost-effectiveness. Therefore, careful patient selection, informed consent, and ongoing monitoring are crucial to achieving favorable outcomes

Looking forward, **refinements in technique**, **newer device generations**, and **comparative long-term studies** are expected to expand the indications and optimize the use of MIGS in routine glaucoma practice. As technology and understanding of aqueous outflow physiology advance, MIGS is poised to become an increasingly integral component of personalized glaucoma management, offering hope for safer and more sustainable vision preservation.

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