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Minimally Invasive Glaucoma Surgery (MIGS) in Coexistent Cataract and Primary Open-Angle Glaucoma: Focus on Bent Ab Interno Needle Goniectomy (BANG)

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ABSTRACT

Background: Primary open-angle glaucoma (POAG) remains one of the leading causes of irreversible blindness worldwide, with intraocular pressure (IOP) being the only modifiable risk factor. Coexistent cataract and glaucoma present a therapeutic challenge, especially in elderly populations. While traditional surgeries such as trabeculectomy offer robust IOP control, they are associated with significant complications. In contrast, minimally invasive glaucoma surgery (MIGS) has emerged as a safer alternative, particularly for patients with mild to moderate glaucoma, offering modest IOP reduction with a favorable safety profile. Among MIGS techniques, Bent Ab Interno Needle Goniectomy (BANG) represents a cost-effective, instrument-sparing procedure that mimics the effects of more expensive MIGS tools like the Kahook Dual Blade and Trabectome. This review aims to explore the role of MIGS, with a specific focus on Bent Ab Interno Needle Goniectomy (BANG), in the surgical management of patients with coexistent cataract and POAG. It compares BANG's efficacy and safety to other MIGS techniques, discusses anatomical and physiological considerations of the anterior chamber, and evaluates the integration of MIGS with phacoemulsification to achieve optimal IOP control with minimal risk.

Conclusion:

MIGS procedures, particularly BANG, offer a promising balance between efficacy and safety for patients with coexistent cataract and POAG. BANG provides a low-cost, minimally invasive approach to enhance aqueous outflow by excising the trabecular meshwork, showing favorable short-term outcomes and minimal complications. Though long-term data remain limited, its simplicity and affordability make it a viable alternative to costlier MIGS devices, especially in resource-limited settings. When performed in combination with phacoemulsification, BANG may reduce surgical burden and improve patient outcomes. Further longitudinal studies are needed to establish its long-term efficacy and durability compared to conventional and other minimally invasive procedures.

Keywords: *Minimally Invasive Glaucoma Surgery,Primary Open-Angle Glaucoma, Cataract, Bent Ab Interno Needle Goniectomy*

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Introduction

Glaucoma is a chronic, progressive optic neuropathy that represents a major global cause of irreversible blindness, with primary open-angle glaucoma (POAG) being its most prevalent form [1]. The disease is characterized by a gradual loss of retinal ganglion cells and visual field defects, typically progressing silently until advanced stages. Among several proposed risk factors, intraocular pressure (IOP) remains the only well-established modifiable factor in slowing or halting disease progression [2,3].

Management of POAG primarily focuses on achieving a target IOP, defined as the pressure below which further optic nerve damage is unlikely. Traditionally, this has been pursued through medical, laser, or surgical interventions [4]. Medical therapy, while effective in many cases, suffers from limitations such as poor adherence, side effects, and limited long-term efficacy [5-7]. On the other hand, surgical options such as trabeculectomy are highly effective in lowering IOP but carry considerable risks, including hypotony, bleb-related infections, and vision-threatening complications [8].

The co-occurrence of cataract and POAG is particularly common in the aging population, necessitating surgical strategies that address both conditions. While phacotrabeculectomy remains a standard approach, its complications and postoperative management challenges have led to growing interest in less invasive options [9,10].

Minimally invasive glaucoma surgery (MIGS) has gained popularity as an intermediate solution, offering modest IOP reduction with a higher safety profile and quicker recovery time. Among MIGS techniques, Bent Ab Interno Needle Goniectomy (BANG) has emerged as a low-cost alternative that replicates the effects of devices like the Kahook Dual Blade and Trabectome without the associated equipment costs [11,12]. This review explores the utility of MIGS — with particular attention to BANG — in the context of combined cataract and glaucoma surgery.

2. Anatomy of the Anterior Chamber and Aqueous Outflow Pathways

The anterior chamber (AC) is the fluid-filled space between the cornea and the iris-lens diaphragm. Its diameter typically ranges from 11.3 to 12.4 mm, and its depth from 2.9 to 3.8 mm, being generally deeper in myopic eyes and shallower in hyperopic ones [13-15].

Aqueous humor is secreted by the non-pigmented epithelial cells of the ciliary processes into the posterior chamber, then flows through the pupil into the anterior chamber. It exits the eye through two major pathways: the conventional trabecular meshwork route and the unconventional uveoscleral route [16,17].

The **conventional pathway** accounts for the majority of aqueous humor drainage. It involves passage through the trabecular meshwork (TM), Schlemm's canal, collector channels, and finally the episcleral

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veins. The TM is composed of three structural layers: the uveal meshwork, the corneoscleral meshwork, and the juxtacanalicular tissue — the latter being the primary site of resistance to aqueous outflow [16-18].

The TM has a triangular cross-sectional shape, with its apex near Schwalbe's line and its base adjacent to the scleral spur. It contains collagen types I, III, IV, V, and VI, as well as glycosaminoglycans, fibronectin, and actin filaments, contributing to its structural integrity and role in IOP regulation [18,19].

The **uveoscleral pathway**, accounting for approximately 10–15% of aqueous drainage, is independent of IOP and involves the flow of aqueous through the ciliary muscle into the supraciliary and suprachoroidal spaces, where it is absorbed by scleral and uveal vessels [16,17].

A detailed understanding of these outflow routes is essential for comprehending the rationale behind MIGS techniques like BANG, which primarily target the trabecular meshwork to enhance outflow and reduce intraocular pressure.

3. Gonioscopy

Gonioscopy is an essential clinical technique used to visualize and evaluate the anterior chamber angle, a critical region for aqueous humor outflow. Under normal circumstances, the angle structures cannot be seen directly due to total internal reflection at the cornea-air interface, as the angle of incidence of light from the chamber exceeds the critical angle [20,21].

To overcome this, gonioscopy utilizes a high-refractive index contact lens that eliminates total internal reflection by replacing the cornea-air interface with a cornea-lens interface, enabling light from the angle to escape and be observed. There are two main types of gonioscopy: **direct** and **indirect** [20,22].

Direct gonioscopy employs a domed contact lens (e.g., Koeppe or Swan-Jacob lenses), providing a natural, upright, panoramic view of the angle structures. It is typically used in an operating room with the patient supine, often under anesthesia. This technique is indispensable during angle surgeries like MIGS, offering real-time visualization during device insertion or tissue manipulation [20,23].

Indirect gonioscopy, more commonly used in outpatient settings, utilizes mirrored lenses such as Goldmann's 3-mirror or Zeiss 4-mirror goniolenses. These lenses reflect the light from the chamber angle to the observer, producing an inverted image of the opposite angle. This technique allows stereoscopic visualization using a slit-lamp and is particularly useful for static and dynamic assessments [21,22].

Indentation gonioscopy, performed using corneal-type lenses, helps differentiate between appositional and synechial angle closure. Gentle pressure on the cornea displaces aqueous to open an appositionally closed angle, while synechial closure remains unchanged [21]. Conversely,

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manipulation gonioscopy involves lens tilting and patient eye movements to visualize structures "over the hill" of a convex iris, as seen in plateau iris or lens-induced angle narrowing [21].

A thorough understanding of gonioscopy techniques is crucial for performing and interpreting angle-based interventions such as BANG and other MIGS procedures.

4. Non-Surgical Treatment of Coexisting POAG and Cataract

Non-surgical management of primary open-angle glaucoma (POAG) remains the cornerstone of initial treatment, especially in early to moderate cases. The primary goal is to reduce intraocular pressure (IOP) to a target level that slows or halts optic nerve damage. This is typically achieved using pharmacological agents, including prostaglandin analogues, beta-blockers, alpha-2 agonists, carbonic anhydrase inhibitors, and cholinergic agents [24,25].

Among these, **prostaglandin analogues** are most effective for IOP lowering and are usually administered once daily. They act by enhancing uveoscleral outflow. Side effects are generally localized, including conjunctival hyperemia, eyelash growth, and iris pigmentation. **Beta-blockers**, while effective, carry systemic risks such as bronchospasm and bradycardia, particularly in elderly patients with comorbidities [26,27].

However, medication-based therapy is limited by challenges such as poor adherence, improper instillation technique, limited ocular penetration, and systemic or local side effects. Complex regimens involving multiple agents further complicate compliance, especially in older patients [25,28].

Laser trabeculoplasty is another non-invasive method for lowering IOP. **Selective laser trabeculoplasty (SLT)** targets pigmented trabecular cells to improve outflow without causing thermal damage, making it repeatable. It has gained popularity as either a first-line or adjunctive treatment, especially when medical therapy fails or is poorly tolerated [29,30].

Despite their benefits, both medical and laser therapies often fail to provide sustained IOP control in moderate-to-severe glaucoma or when advanced optic nerve damage is present. In such cases, surgical interventions become necessary.

While these non-surgical approaches form the foundation of initial glaucoma management, they are often insufficient for long-term control in eyes with coexisting cataract, leading to increased reliance on surgical strategies such as MIGS or trabeculectomy.

5. Minimally Invasive Glaucoma Surgery (MIGS): Mechanisms, Devices, and Surgical Approaches

Minimally invasive glaucoma surgery (MIGS) represents a growing category of surgical procedures designed to lower intraocular pressure (IOP) with a high safety profile and minimal tissue disruption. MIGS bridges the gap between medical/laser therapy and traditional filtering surgeries like trabeculectomy or tube shunt implantation [31,32].

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What distinguishes MIGS procedures is their ab interno approach—accessing the anterior chamber angle via a clear corneal incision while sparing the conjunctiva and sclera. This allows for quicker recovery, less postoperative inflammation, and preservation of tissue for future interventions [33].

Mechanistically, MIGS procedures can be divided into three major categories:

1. **Trabecular outflow enhancers**, which remove or bypass the trabecular meshwork to facilitate aqueous drainage through Schlemm's canal. Examples include the **iStent**, **Hydrus Microstent**, **Kahook Dual Blade (KDB)**, **Trabectome**, and **BANG** [34,35].
2. **Suprachoroidal shunts**, which direct aqueous humor from the anterior chamber to the suprachoroidal space. These include the **iStent Supra**, **CyPass (withdrawn)**, and **MINIject**. Though promising, many of these devices are under ongoing evaluation due to safety concerns such as endothelial cell loss [36,37].
3. **Subconjunctival drainage devices**, like the **XEN Gel Stent** and **PRESERFLO MicroShunt**, which mimic the principles of trabeculectomy but with a less invasive technique [38].

From a surgical standpoint, MIGS can be performed alone or in combination with cataract extraction. When combined with phacoemulsification, MIGS procedures may provide added IOP reduction with minimal additional risk—making them particularly appealing in patients with coexisting cataract and glaucoma [39].

While MIGS generally provides a modest IOP reduction compared to trabeculectomy, the safety profile is considerably better. As a result, MIGS is most appropriate for patients with mild-to-moderate glaucoma or those intolerant to medications but not yet requiring extensive IOP lowering [32,33].

6. Bent Ab Interno Needle Goniectomy (BANG): Concept and Outcomes

Bent Ab Interno Needle Goniectomy (BANG) is a low-cost, minimally invasive surgical technique designed to improve aqueous humor outflow by excising a strip of the trabecular meshwork (TM) and the inner wall of Schlemm's canal. This procedure draws inspiration from commercially available MIGS tools like the Kahook Dual Blade and Trabectome but utilizes a simple, bent 25-gauge hypodermic needle to create a double-blade goniotome [40].

The needle is manually bent near the bevel to form a >90° angle, producing two opposing cutting edges. This design allows en bloc removal of TM tissue with minimal collateral damage. The posterior portion of the needle acts as a guard to prevent injury to the outer wall of Schlemm's canal. The result is a cost-effective alternative for angle surgery, especially in resource-limited settings [41].

Unlike simple goniotomy, which merely incises the TM, BANG removes a full strip of tissue, reducing the risk of post-operative fibrosis and re-closure of the outflow pathway. This approach is theorized to improve the durability of IOP reduction over time [41].

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Clinical outcomes reported by Townsend et al. and Shute et al. indicate that BANG can achieve a ≥20% reduction in IOP in approximately 70–75% of patients by 6 months postoperatively. A substantial proportion of these patients required no anti-glaucoma medications, qualifying as complete surgical success [40,41].

Moreover, the technique has shown a favorable safety profile. Most reported complications are mild and transient, such as self-limiting hyphema. No serious adverse events like hypotony, infection, or suprachoroidal hemorrhage were observed in early clinical series [41].

While long-term data remain limited, BANG offers an accessible, efficient alternative for glaucoma management, especially in eyes with coexisting cataract undergoing combined surgery. Its affordability and safety make it an attractive choice in clinical practice where specialized MIGS devices are unavailable.

7. Clinical Comparison Between BANG + Phacoemulsification vs Phacotrabeculectomy

In managing patients with coexisting cataract and primary open-angle glaucoma (POAG), the choice of surgical approach depends on the target intraocular pressure (IOP), disease severity, and the patient's ability to tolerate medications or complex postoperative care. Traditionally, **phacotrabeculectomy** has been the standard combined procedure, offering substantial IOP reduction by creating a guarded filtering bleb. However, due to its invasive nature and higher complication rates, newer alternatives like **BANG combined with phacoemulsification** have garnered increasing attention [42,43].

Phacotrabeculectomy has a proven record of lowering IOP significantly and reducing the need for glaucoma medications, especially in eyes requiring tight IOP control. Nevertheless, its drawbacks include a steep learning curve, the risk of hypotony, bleb-related infections, wound leaks, and the need for intensive postoperative management [42]. Success depends heavily on maintaining bleb function, which may be compromised by fibrosis and scarring over time [43].

In contrast, **BANG combined with phacoemulsification** represents a safer, less invasive option. It preserves the conjunctiva, avoids bleb-related complications, and is relatively easy to perform with basic surgical tools. Although it typically achieves **modest IOP reduction**, it is often sufficient for patients with **mild to moderate glaucoma** or those with intolerance to medications. Studies have reported encouraging outcomes, showing IOP reductions around 20–30% with significant medication reduction, and minimal complications such as transient hyphema [40,41,44].

The key limitation of BANG is its **lower efficacy** compared to phacotrabeculectomy, especially in advanced glaucoma or cases requiring very low target IOP. Moreover, its **long-term durability** remains to be established, and further head-to-head comparative trials are needed.

Overall, **BANG + phacoemulsification** may be considered a reasonable alternative for selected patients—especially those desiring faster recovery, lower risk of complications, and reduced

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dependence on anti-glaucoma medications—while **phacotrabeculectomy remains preferred in advanced disease** or when aggressive IOP lowering is essential [42–44].

8. Conclusion

The management of coexisting cataract and primary open-angle glaucoma (POAG) continues to evolve, with a growing emphasis on procedures that strike a balance between efficacy and safety. While **phacotrabeculectomy** remains a gold-standard combined surgery for patients with advanced glaucoma and low target IOP requirements, it carries considerable risks, including hypotony, bleb failure, and a demanding postoperative course

In contrast, **Bent Ab Interno Needle Goniectomy (BANG)** combined with **phacoemulsification** represents a promising alternative, especially in cases of mild-to-moderate glaucoma or in patients unsuitable for invasive filtering surgery. BANG offers meaningful IOP reduction, a reduction in medication burden, and a safer postoperative profile, all while being cost-effective and technically accessible. Its conjunctiva-sparing nature also preserves the option for future traditional surgery if needed [40,41,44].

Although current data support the short-to-medium-term efficacy and safety of BANG, **long-term outcomes and large-scale comparative trials** remain necessary to define its definitive role. As minimally invasive glaucoma surgery (MIGS) gains ground in modern ophthalmology, BANG may be particularly valuable in low-resource settings and in patients desiring less aggressive intervention.

Ultimately, **surgical decision-making should be individualized**, considering disease severity, patient comorbidities, medication tolerance, and surgical risk. For many patients with coexisting cataract and POAG, BANG with phacoemulsification offers an attractive blend of simplicity, safety, and effectiveness.

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