보건의료인용

Cataract surgery combined with glaucoma surgery[1]

Torbey J, Mansouri K. *Curr Opin Ophthalmol* 2025;36(1):54-61.

Purpose

본 리뷰는 백내장 수술과 병행한 녹내장 수술의 임상적 근거를 정리하고 평가하였습니다.

Summary

- 장기 녹내장 환자의 경우 백내장이 조기에 더 자주 발생하는 경향이 있습니다. 최근 연구에 따르면 섬유주절제술 (trabeculectomy) 단독과 백내장 병행 수술(phaco-trabeculectomy) 간의 수술 후 안압(IOP) 조절 효과는 유사하였으며, 오히려 병행 수술의 합병증 발생률이 더 낮은 것으로 보고되고 있습니다.

- Minimally invasive bleb surgeries(MIBS)는 전방에서 방수를 결막 아래로 배출하는 방식으로, 기존 여과수술보다 안전한 대안으로 개발되었습니다. 연구에 따르면 이러한 수술 기법은 단독 또는 백내장 수술과 병행 시 안압 감소 효과와 약물 사용 감소에서 유의미한 차이가 없었으며, 5년 추적 연구에서 안압 감소와 높은 약물 중단율이 보고되었습니다. 특히 ab-externo 접근법은 ab-interno 접근법과 비교했을 때 더 정밀한 장치 배치가 가능하며, 섬유화 발생 위험을 낮추고 여과포 조작(needling) 비율 또한 더 낮았습니다. 이러한 차이는 수술 기기의 물질적 특성뿐만 아니라 수술 접근법의 차이에 기인할 가능성이 있으나 보다 명확한 평가를 위해 장기적인 연구가 필요합니다.

- 각막각(trabecular meshwork)과 슐렘관(Schlemm's canal)을 활용하는 각 기반(angle-based) 수술은 기존 여과수술보다 조직 손상을 최소화하면서 안압(IOP) 감소를 목표로 합니다. 연구 결과, 이러한 수술 기법을 백내장 수술과 병행할 경우 단독 수술보다 더 효과적인 안압 감소 및 약물 사용 감소 효과를 보였습니다.

- 공막하맥락막(suprachoroidal) 경로는 높은 안압(IOP) 감소 가능성을 가진 유망한 접근법으로 여겨지지만, 아직 그 기전이 명확히 밝혀지지 않았습니다. 새로운 공막하맥락막 삽입 장치는 특수 소재를 활용해 supraciliary space에 삽입되며, 3건의 임상시험(meta-analysis)에서 2년간 IOP 감소 효과 및 양호한 안전성을 보였습니다. 그러나 백내장 수술과 병행한 결과는 아직 보고되지 않았습니다.

- 내시경적 섬모체광응고술(ECP)은 기존의 섬모체파괴술(cyclodestructive procedures)에 대한 대안으로 개발되었으며, ab-interno 접근법을 통해 섬모체를 정밀하게 표적화하면서 주변 조직 손상을 최소화할 수 있습니다.6년간의 후향적 연구에서 백내장 수술과 ECP를 병행(Phaco-ECP)한 84안에서 평균 IOP가 유의미하게 감소하였으나 68%가 6년 내 수술 실패로 분류되었습니다. Phaco-ECP는 감염, 저안압(hypotony) 등 합병증 발생이 적고 회복이 빠른 장점이 있지만, 장기적인 수술 성공률은 상대적으로 낮아 추가 치료가 필요할 가능성이 있다.

Conclusion

전반적으로, 백내장 수술과 MIGS 병행은 약물 부담을 줄이고 침습적 수술을 늦출 수 있어 선호되는 접근법이 되고 있다. 하지만 연구 설계와 성공 기준이 다양하여 비교가 어렵고, 최적의 병행 수술 방식을 결정하기 위해 추가 연구 및 표준화가 필요하다.

MIBS
(minimally invasive bleb surgery)[1]

기존의 여과수술보다 더 안전한 대안으로 개발되었으며, 개방각 녹내장에서
전방방수(anterior chamber aqueous humor)를 결막하 공간(subconjunctival space)으로 배출하는 방식입니다.
단독 수술로 시행될 수도 있고, 백내장 수술과 병행하여 시행될 수도 있습니다.

Astream®은 국내에서 처음으로 제조된 녹내장 임플란트로, 움직이는 안구에서도 원형을 유지하여 효과적으로 안압이 강하되도록 설계된 MIBS device입니다.

Astream® 특장점

강력한 안압 강하 효과와
장기간 높은 안압 유지율[2]

안압 강하 약물
사용 부담 감소[2]

높은 수술 성공률 및
우수한 안전성 프로파일[3]

1. Torbey J, Mansouri K. *Curr Opin Ophthalmol* 2025;36(1):54-61. **2.** Ahn BH, et al. *Clin Exp Ophthalmol* 2016;44:776-782. **3.** Park HM, et al. *Eye (Lond)* 2025. doi: 10.1038/s41433-025-03728-y. Online ahead of print.

Astream®은 의료기기이며 사용시 주의사항을 잘 읽고 사용하시기 바랍니다.

PRODUCT INFORMATION

[제품명] 에이스트림®(Astream®) **[품목명]** 안구밸브임플란트 B03290.01 (3) **[사용 목적]** 녹내장 치료를 위해 환자 눈의 안압을 조절하고 녹내장의 진행을 막기 위해 고안된 녹내장 배액장치로, 전방과 공막 사이 결막 하 공간으로 방수를 배출시킴으로써 안압을 조절한다. 약물 및 레이저 치료로 조절되지 않는 녹내장 환자와 수술 결과가 좋지 않은 환자를 위해 사용한다. **[사용 시 주의사항]** 1) 본 제품의 수술 및 시술은 반드시 숙련된 안과 전문의만 사용하도록 한다. 2) 사용 전 제품의 상태(포장 및 제품 이상 여부, 멸균 상태, 유효기간 등)를 주의 깊게 확인한다. 3) 본 제품은 일회용 제품으로 재사용을 금한다. 4) 사용하지 않은 제품의 포장이 개봉되어 있을 경우 사용하지 않고, 교환을 위해 제조사로 반환한다. 5) 유통기한이 지난 제품은 사용하지 않는다. [저장 방법] 건조한 실온(30°C 이하)에서 보관 **[포장 단위]** 1EA/1box

※ 자세한 제품 정보는 제품 설명서를 참조해 주십시오.

MICROT | 경기도 성남시 중원구 사기막골로 99, B동 1504~1507호(성남센트럴비즈타워2차)
TEL. 031-731-1238 I Homepage www.microtinc.com

astream®
Glaucoma Implant

REVIEW

Cataract surgery combined with glaucoma surgery

Julien Torbey[a] *and Kaweh Mansouri*[a,b]

Purpose of review
This review evaluates the surgical management of glaucoma in patients undergoing cataract surgery. Combining both procedures present challenges in balancing intraocular pressure (IOP) control, minimizing postoperative complications, and achieving optimal refractive outcomes.

Recent findings
Recent studies highlight the effectiveness of combined glaucoma and cataract surgeries, with traditional filtering surgeries and MIGS showing significant IOP reduction. The abundance of long-term studies shows that MIGS can offer an effective and safer alternative when carefully tailored to meet the specific needs of each patient.

Summary
Combining glaucoma and cataract surgery is a promising approach for patients with coexisting conditions. While traditional surgeries offer robust IOP reduction, MIGS procedures offer better safety profiles with fewer complications and more predictable refractive results. Surgeons must carefully consider the timing and choice of procedures, with further research required to develop standardized treatment algorithms.

Keywords
cataract surgery, glaucoma, intraocular pressure, minimally invasive glaucoma surgery, refractive outcomes

INTRODUCTION

Glaucoma remains one of the leading causes of blindness and a significant treatment burden worldwide [1]. Performing cataract surgery in glaucoma patients presents a challenging scenario due to the complexity of managing intraocular pressure (IOP), while balancing safety and optimizing visual outcomes.

Phacoemulsification with intraocular lens (IOL) implantation significantly lowers IOP, with more pronounced reductions in eyes with higher preoperative IOP. This suggests that the aging crystalline lens is crucial in ocular hypertension and open-angle glaucoma [2,3]. While this reduction may be sufficient in early-stage cases, combining glaucoma procedures with cataract surgery can enhance the effect [4].

Traditional filtering surgeries, such as trabeculectomy, are still considered the gold standard in glaucoma management and are often performed in combination with cataract surgery. Although highly effective at reducing IOP, they require intensive postoperative follow-up and are associated with potential complications like hypotony, blebitis, and bleb-related interventions [5].

When combined with lens removal, the emergence of minimally invasive glaucoma surgeries (MIGS) offers the potential to reduce further IOP and the need for ocular hypotensive medications (OHMs). MIGS aims to provide a safer alternative with minimal surgical recovery time. Various MIGS techniques and devices are available, including angle surgeries via trabecular or suprachoroidal approaches, bleb-forming implants, and ciliary body treatments. Although the evidence supporting MIGS is growing, the procedures are still evolving, and long-term randomized controlled studies are limited [6,7].

This review summarizes the evidence on glaucoma surgeries combined with cataract surgery.

MATERIALS AND METHODS

The literature review was refined to include studies combining glaucoma and cataract surgeries, with publications on standalone surgeries mentioned

[a]Swiss Visio Glaucoma Research Center, Montchoisi Clinic, Lausanne, Switzerland and [b]Department of Ophthalmology, University of Colorado School of Medicine, Denver, Colorado, USA

Correspondence to Kaweh Mansouri, MD, MPH, Swiss Visio Glaucoma Research Center, Montchoisi Clinic, Lausanne 1006, Switzerland. Tel: +41 58 274 22 00; fax: +41 (21) 619 36 28. e-mail: kwmansouri@gmail.com

Curr Opin Ophthalmol 2025, 36:54–61
DOI:10.1097/ICU.0000000000001105

KEY POINTS

- Combining cataract and glaucoma surgery is a well tolerated and effective approach for managing both conditions simultaneously.
- MIGS procedures offer safer, more predictable refractive results than traditional filtering surgeries.
- Further studies are needed to establish standardized guidelines for combined procedures.

briefly when relevant. Given the lack of randomized controlled trials (RCTs) for MIGS, preference was given to multicentric, recent, and long-term studies when available. Although the list of procedures and devices reviewed is not exhaustive, it broadly represents the range of available surgical options.

FILTERING SURGERIES

Trabeculectomy has evolved over the years. This procedure remains highly caractogenic on phakic patients. Also, long-term glaucoma patients appear to develop cataracts earlier and more frequently, which leads to a problem of decisions to address both diseases [8].

Combining trabeculectomy with cataract extraction has been widely performed. The understanding was that trabeculectomy alone is more effective than a combined procedure [9,10]. Most of the evidence relied on publications that did not perform trabeculectomy with MMC but either 5-FU or no antimetabolites. More recent studies tend not to follow the same trend, with no significant difference in postoperative IOP control between phaco-trabeculectomy and trabeculectomy, while the complication rate was significantly lower with the combined procedure [11–13].

There is yet to be a clear consensus on whether cataract surgery and trabeculectomy should be performed as a combined procedure, sequentially, or on the ideal order if done sequentially [11,14]. However, performing cataract surgery early after trabeculectomy has been reported to induce bleb failure in 10–35% of cases [4,15].

MINIMALLY INVASIVE BLEB SURGERIES

Minimally invasive bleb surgeries (MIBS) have been developed as bleb-forming, safer alternative to traditional filtering surgeries that drain the aqueous humor from the anterior chamber to the subconjunctival space for open-angle glaucoma. Two widely available devices on the market are the XEN Gel Stent (XEN) (Allergan, Irvine, USA), made from porcine gelatin, and the PreserFlo MicroShunt (PMS) (Santen, Japan), made from a synthetic polymer. Both procedures can be performed as standalone surgeries or in combination with cataract surgery [16].

The prospective study by Mansouri *et al.* [17▪] compared standalone XEN 45 gel stent implantation to combined phacoemulsification and XEN (Phaco + XEN) in 170 eyes over 5 years. There was no significant difference in the outcomes between the two groups. In the standalone XEN group, mean IOP was reduced from 19.6 ± 7.1 to 12.5 ± 3.1 mmHg at 5 years ($P < 0.01$) vs. the Phaco + XEN group, mean IOP reduced from 19.8 ± 7.0 to 12.6 ± 3.1 mmHg at 5 years ($P < 0.01$). Both groups experienced a reduction in IOP-lowering medications from 2.0 ± 1.3 to 0.8 ± 1.1 ($P < 0.01$), with no significant difference between the two groups in IOP reduction or medication reduction throughout the 5-year follow-up ($P > 0.05$). The study found that needling was required in 49% of all eyes (84 out of 170), with no significant difference between the standalone XEN and Phaco + XEN groups. Compared to the literature, the study's needling rate falls within the reported range of 30–50%, consistent with other studies.

Similarly, in a retrospective real-life study by Jacob *et al.* [18] (eye), 259 consecutive surgeries (187 XEN vs. 72 XEN + Phaco) were analyzed. No statistical differences were found in postoperative IOP reduction, OHMs, adverse events, and complications [18].

Martínez-de-la-Casa *et al.* [19] compared the Preserflo MicroShunt (PMS) alone vs. PMS combined with cataract surgery (PMS + Phaco) in 58 eyes with open-angle glaucoma, finding superior success rates for the combined procedure (80 vs. 60%) after 12 months, with both groups showing significant IOP reduction (from 21.5 to 14.6 mmHg) and a decrease in medications ($P < 0.0001$). A 5-year study of 23 patients with PMS, including combined procedures, showed a 46.7% IOP reduction (from 23.8 to 12.4 mmHg) and 61.1% medication-free rate and similar outcomes between standalone and combined procedures, with no sight-threatening adverse events [20].

In comparative studies, the rate of needling was lower for the PRESERFLO MicroShunt compared to the Xen Gel Stent, which may be attributed to the difference in composition and its precise placement as an ab-externo procedure, reducing fibrosis at the stent's tip. However, longer-term studies are still needed to fully assess these outcomes [21].

ANGLE SURGERIES

Angle-based procedures target the conventional outflow pathway by enhancing aqueous humor drainage through the trabecular meshwork and Schlemm's canal. These procedures are designed to lower IOP with minimal tissue disruption compared to traditional filtering surgeries.

The trabecular bypass iStent (Glaukos Corp., Laguna Hills, California, USA) is a titanium device designed to bypass the diseased trabecular meshwork. The size and number of devices implanted in recent years have evolved with each new iteration.

The various iterations of the iStent are among the most studied devices, with long-term follow-ups extending up to 7 years [22]. The iStent Inject Study Group published a randomized controlled multicenter study on 505 eyes, comparing combined iStent (second generation) and cataract surgery vs. standalone cataract surgery. The combined group showed a more significant reduction in IOP and OHMs at 2 years, with 75.8% of eyes achieving a more than 20% medication-free diurnal IOP reduction (-7.0 ± 0.3 mmHg), compared to 61.9% (-5.4 ± 0.3 mmHg) in the standalone group ($P = 0.005$), and a mean decrease in OHMs of 1.2 ± 1.0 in the combined group vs. 0.8 ± 1.0 in the standalone group ($P < 0.001$). Across all eyes, the 24-month IOP ranged from 15.5 to 17.2 mmHg for the combined group and 15.9–17.8 mmHg for the standalone group.

No significant differences in postoperative adverse events were reported, with no cases of hypotony, hypotony-related complications, or hyphema.

The Hydrus Microstent (Ivantis, Inc., Irvine, California, USA) is a longer, curved scaffold made of a nickel-titanium alloy, designed to be placed in the angle. Once in place, it dilates the collapsed Schlemm's canal to improve IOP drainage.

The multicentric RCT HORIZON trial compared cataract surgery combined with the Hydrus microstent to standalone cataract surgery with 5 years follow-up [23]. The combined group with a baseline unmedicated IOP of 25.5 + -0 mmHg had more IOP reduction ($-8.3 + -3.8$ mmHg) in comparison to the control group which ($-6.5 + -4.0$ mmHg) from preoperative baseline of $25.4 + -2.9$ mmHg ($P < 0.001$) with a significantly higher percentage of eyes with an IOP of 18 mmHg or less for the combined group (49.5 vs. 33.8%; $P = 0.003$) at 5 years. Similarly, the combined group had a lower mean OHMS of $0.5 + -0.9$ than the control group, $0.9 + -0.9$ ($P < 0.001$), which led to lower additional surgeries to control IOP. Furthermore, 14.6% of eyes had peripheral anterior synechiae in the microstent group vs. 3.7% for the control ($P = 0.0001$), the only significant adverse event reported. It also demonstrated a protective effect of the Hydrus Microstent, with a slightly nonsignificant lower rate of visual field progression compared to cataract surgery alone (8.4 vs. 9.6%) ($P = 0.63$).

Goniotomy is a MIGS that involves creating an incision in the trabecular meshwork to enhance aqueous humor outflow with minimal tissue disruption.

A multicenter study comparing goniotomy with the Kahook Dual Blade (KDB) and iStent trabecular bypass in glaucoma patients undergoing cataract surgery found that KDB led to greater IOP and medication reductions, with a 23.7% IOP drop in the KDB group vs. 16.4% in the iStent group, and fewer IOP spikes ($P < 0.001$) [24].

The KDB showed greater success when combined with cataract surgery, with 76% of the KDB-phaco group achieving at least 20% IOP reduction at 24 months compared to 47% in the KDB-alone group, though hyphema and IOP spikes were the most common complications [25].

Canaloplasty is a MIGS that improves natural aqueous outflow by dilating Schlemm's canal.

Canaloplasty is one approach that, combined with cataract surgery, produced an IOP reduction from 41 up to 56%, compared to 30–34% for canaloplasty alone. Additionally, medication dependency dropped significantly, with reductions ranging from 64 to 88% in the combined procedures in comparison to 53–76% for the standalone procedure. These outcomes indicate that combining canaloplasty with cataract surgery is highly effective for patients with mild-to-moderate open-angle glaucoma, offering greater pressure reduction and fewer complications [26].

SUPRACHOROIDAL PATHWAY

The suprachoroidal pathway has been touted as promising but poorly understood. Suprachoroidal devices have high IOP-lowering potential, but questions remain about their safety profile. The Cypass device was retracted from the market after it was shown detrimental endothelial cell count results.

The MINIject is a newer suprachoroidal device that utilizes the proprietary STAR material designed for implantation in the supraciliary space. The meta-analysis of the STAR-I, II, and III trials demonstrated that the MINIject supraciliary implant effectively reduced IOP in patients with primary open-angle glaucoma. Over 2 years, the mean IOP was reduced by 39.3%, with 37.9% medication-free patients at 2 years and a favorable safety profile, with a mean endothelial cell density (ECD) loss of only 6.2% [27]. To date, no publications have reported its outcomes as a combined procedure.

ENDOSCOPIC CYCLOPHOTOCOAGULATION

Endoscopic cyclophotocoagulation (ECP) has been developed as an alternative to traditional cyclodestructive procedures. The ab-interno approach with better visualization allows for more precise targeting of the ciliary body while minimizing the effect on the surrounding structures.

A 6-year retrospective case series on combined phacoemulsification and ECP (Phaco-ECP) surgery in 84 eyes with uncontrolled glaucoma found a significant reduction in IOP. The mean IOP dropped from 18.9 mmHg preoperatively to 12.3 mmHg at the 6-year mark ($P < 0.001$). However, 68% of eyes were classified as surgical failures by the 6-year point, with 36% failing due to inadequate IOP control and 32% requiring further laser or surgery. Postoperative complications were uncommon, with 11% of eyes experiencing complications and only 2.4% requiring additional surgical intervention [28].

Phaco-ECP was associated with fewer postoperative complications than trabeculectomy, such as infection or hypotony, and shorter recovery times [29].

Table 1 provides an overview of above technologies.

ENDOTHELIAL CELL DENSITY

Cataract surgery alone can induce ECD loss. Recent studies show around 11% ECD loss after routine phacoemulsification [30]. Combined procedures should aim to balance IOP reduction and ECD safety to prevent corneal decompensation. The CyPass device was retracted from the market due to concerns about significant ECD loss. Ongoing investigations continue to assess the safety of other devices and procedures, summarized in Table 2.

Trabeculectomy alone results in less endothelial cell loss (6.35–17.9%) compared to combined phaco-trabeculectomy, where cell loss is significantly higher (31.6% for one-step, $P < 0.0001$, and 42.6% for two-step, $P = 0.027$). The two-step procedure causes more endothelial damage due to the cumulative effect of two surgeries ($P < 0.0003$). Therefore, one-step phaco-trabeculectomy is recommended to minimize ECD loss when managing coexisting glaucoma and cataract [31,32].

Olgun *et al.* [33] demonstrated that standalone XEN (−2.1% +− 13.8%) appeared to be safer for the endothelium than traditional filtering surgeries (−10.0% +− 9.7%) at 3 months ($P = 0.002$). Furthermore, combined XEN surgery (−14.3%, $n = 17$) produced similar magnitude ECD loss at 2 years in comparison to phaco-emulsification alone (−14.5%, $n = 15$) ($P = 0.226$) [34]. Those studies have a limited sample size and short-term follow-up, and the effect on ECD should be investigated further.

Two studies evaluated the impact of PRESERFLO MicroShunt implantation on ECD loss over 12 months. In both, the average ECL was 7.4%, with one study showing statistical significance ($P = 0.04$) while the other did not ($P = 0.08$). Both studies found that ECD loss was significantly higher when the implant was closer to the corneal endothelium. The findings highlight the importance of correctly positioning the shunt to minimize endothelial damage [35,36].

ECD loss was similar between the two groups and consistent with reported percentages in the literature for the i-stent [22]. Similarly, the rate of ECD loss was not statistically significant ($P = 0.261$) between the two standalone and combined Hydrus groups (13 vs. 11%) [23].

In the study by Dorairaj and Balasubramani [37] comparing excisional goniotomy with the KDB and the iStent, the KDB-phaco group experienced an (ECD) loss of 3.4% over an average follow-up of 18.2 months, while the iStent-phaco group had a significantly greater ECD loss of 9.0% ($P = 0.013$). This suggests that KDB may result in less endothelial cell loss than the iStent when combined with cataract surgery [37].

In summary, no definitive evidence suggests that MIGS devices result in higher ECD loss than other glaucoma surgeries. However, long-term studies are required to understand better and assess the potential effects of these devices on ECD over time [38].

REFRACTIVE OUTCOMES

Glaucoma patients have been shown to produce more refractive surprises after cataract surgery. This appears more pronounced in patients with pseudoexfoliation, high axial length, and chronic angle closure pathologies [39,40].

Combined cataract and trabeculectomy displayed more surgically induced astigmatism, axial length changes, and postoperative myopic shift [41,42]. Patients who underwent cataract surgery alone achieved better refractive outcomes (85%, $P = 0.001$) and had less induced astigmatism than those who had combined surgery. The mean induced cylinder was 1.31D for the combined surgery group, compared to 0.99D for the cataract-only group ($P = 0.11$) [43]. No consensus exists on whether cataract surgery following trabeculectomy might affect postoperative refraction [44,45].

Refractive outcomes have also been assessed for minimally invasive procedures [46]. Most procedures, such as the XEN [47], PreserFlo [48], trabecular microbypass stents [49,50], Hydrus [51], and goniotomy [52] appeared to be refractive neutral. Mild transient surgically induced astigmatism was observed due to the placement of the incisions.

A trend toward a postoperative myopic shift was observed in combined ECP procedures [53,54] (Table 2).

Table 1. Minimally invasive glaucoma surgeries intraocular pressure, ocular hypotensive medications, and adverse events

Procedure	IOP reduction	OHM	Comments
XEN Gel Stent [17■]	IOP reduced from 19.6 ± 7.1 to 12.5 ± 3.1 mmHg (standalone) and from 19.8 ± 7.0 to 12.6 ± 3.1 mmHg (combined) over 5 years ($P < 0.01$).	Medications reduced from 2.0 ± 1.3 to 0.8 ± 1.1 ($P < 0.01$).	Effective in lowering IOP and reducing medications, but the needling rate is relatively high (30–50%). No significant difference between standalone or combined procedures.
PRESERFLO MicroShunt [56]	IOP reduced from 23.4 to 13.8 mmHg (standalone) and from 23.47 to 11.62 mmHg (combined) after 12 months.	Significant reduction, with no medications needed in the combined group.	Lower needling rates compared to XEN (5–18%); the ab-externo approach allows precise placement, reducing fibrosis at the stent's tip. Long-term outcomes are promising, with effective IOP reduction and medication elimination in many patients.
iStent (2nd gen) [22]	IOP reduction of 7.0 mmHg in combined group vs. 5.4 mmHg in cataract-only group ($P = 0.005$).	Medications reduced by 1.2 OHMs in combined group vs. 0.8 OHMs in standalone group ($P < 0.001$).	Shows significant IOP and medication reduction when combined with cataract surgery. Long-term studies support efficacy over up to 7 years with no major adverse events.
Hydrus Microstent [23]	IOP reduction of −8.3 mmHg (combined group) vs. −6.5 mmHg (cataract surgery alone) from preop baseline of ∼25.5 mmHg ($P < 0.001$).	Lower medication use in combined group (0.5 OHMs) vs. control group (0.9 OHMs) ($P < 0.001$).	Effective in reducing IOP and medication burden when combined with cataract surgery. Lower rates of additional surgeries required compared to standalone cataract surgery. Peripheral anterior synechiae occurred more frequently.
Kahook Dual Blade (KDB) [25]	IOP reduction of 23.7% (KDB group) vs. 16.4% (iStent group) ($P < 0.001$).	Medications reduced from 1.7 to 0.6 in KDB group vs. 1.9 to 1.0 in iStent group ($P = 0.001$).	KDB provides greater IOP and medication reduction compared to iStent, with fewer IOP spikes. More effective when combined with cataract surgery.
MINIject (Suprachoroidal) [57■]	IOP reduction by 39.3%, from 23.8 to 14.4 mmHg over 2 years ($P < 0.0001$).	37.9% of patients became medication-free at 2 years.	Significant IOP reduction and a favorable safety profile, including minimal endothelial cell loss. Further research is needed to assess its outcomes when combined with cataract surgery.
Endoscopic cyclophotocoagulation (ECP) [29]	IOP reduction from 18.9 mmHg preop to 12.3 mmHg at 6 years ($P < 0.001$).	25–84.6% depending on the study and patient characteristics	ECP offers significant IOP reduction but has a high failure rate over time. Postoperative complications are fewer compared to trabeculectomy, though long-term control may be limited.

Table 2. Refractive outcomes for combined cataract and glaucoma procedures

Study	Procedure type	Findings	Conclusion
Bae *et al.* [45]	Trabeculectomy + cataract surgery vs. cataract alone	Myopic shift more common in combined surgery, with mean error of −0.48 vs. −0.22 D for cataract alone ($P < 0.05$).	Combined surgery impacts refractive outcomes with surgically induced astigmatism.
Dorairaj *et al.* [24]	KDB vs. iStent with Phacoemulsification	Less refractive error in the KDB group (mean error -0.3 D) compared to iStent group (mean error −0.55 D, $P = 0.017$).	KDB provides better refractive stability when combined with cataract surgery.
Tatti *et al.* [47]	XEN Gel Implantation	No significant changes in refractive outcomes, with stable keratometry readings and anterior chamber depth ($P > 0.05$).	XEN Gel does not affect corneal curvature or refractive outcomes.
Manoharan *et al.* [39]	Kahook Dual Blade goniotomy combined with phacoemulsification	Minimal induced astigmatism with a mean change of 0.28 D. No significant postoperative refractive surprises ($P > 0.05$).	KDB combined with cataract surgery is effective for IOP control with minimal refractive impact.
Ibarz Barberá *et al.* [48]	PRESERFLO Microshunt (standalone and combined with cataract surgery)	Mild increase in corneal astigmatism: anterior surface 0.4 ± 0.3 D and posterior surface 0.08 ± 0.1 D at 3 months ($P = 0.01$). Axial length decreased by 0.13 ± 0.23 and 0.2 ± 0.07 mm ($P = 0.01$).	Induces mild and transient changes in corneal astigmatism and axial length, with no long-term impact on refractive outcomes.
Sheybani *et al.* [53]	Phaco-ECP vs. Phaco alone	Significant myopic shift in the Phaco-ECP group, with a mean refractive error of −0.50 D compared to phaco alone ($P < 0.001$).	Surgeons should consider adjusting IOL power in Phaco-ECP to mitigate refractive surprises.

IOL selection should be individualized for glaucoma patients. Aspheric IOLs are recommended for their ability to enhance contrast sensitivity. Toric IOLs should be used cautiously, particularly in combined surgeries that may induce astigmatism, such as filtering procedures, or in eyes with weak zonular supports, such as PXF. The use of multifocal and extended depth of focus lenses remains controversial in glaucoma patients, as they can decrease contrast sensitivity, a common issue associated with the disease. Thus, these lenses may be suitable for glaucoma suspects or ocular hypertensive patients but should be avoided in more advanced glaucoma cases [55].

CONCLUSION

Concomitant cataract and glaucoma surgery presents significant challenges due to the absence of standardized protocols and the limited availability of high-quality studies, particularly RCTs. While filtering surgeries effectively lower IOP, combining them with cataract surgery can increase the risk of complications such as bleb failure and unpredictable refractive outcomes. It is often preferred to separate these procedures, especially in advanced glaucoma cases where aggressive IOP reduction is needed.

MIGS have emerged as a favorable option, particularly in less severe cases, due to their safer profile, reduced complication rates, and minimal impact on refractive outcomes when combined with cataract surgery. While they may not achieve as low an IOP as filtering surgeries, they offer a better balance of safety and efficacy, making them suitable for patients who do not require aggressive IOP reduction. Furthermore, MIGS do not significantly contribute to endothelial cell loss, which is a concern with more invasive procedures. They should be tailored to the severity of the patient's glaucoma and the required postoperative IOP reduction, with less potent angle-based procedures offering a safer profile, while bleb-related MIGS, though more effective in lowering IOP, carry a higher risk of complications. However, careful planning is critical to anticipate potential refractive surprises, especially for high-risk patients.

Overall, combining cataract surgery with MIGS is becoming an increasingly popular approach due to its safety and ability to reduce the medication burden while delaying more invasive surgeries. However, variability in study designs and success criteria makes comparing outcomes across different techniques difficult. Further research and standardization are needed to determine the optimal approach for combining cataract and glaucoma surgery.

Acknowledgements

None.

Financial support and sponsorship

This work was partly supported by the Swiss Glaucoma Research Foundation, Lausanne, Switzerland.

Conflicts of interest

B. Financial Disclosures: Mansouri K: Santen (C), Abbvie (C), ImplanData (C), New World Medical (C), Théa Pharma (C), iStar Medical (C), Alcon (S). All other authors indicate no financial support or conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- ▪ of special interest
- ▪▪ of outstanding interest

1. Mansouri K, Medeiros FA, Weinreb RN. Global rates of glaucoma surgery. Graefes Arch Clin Exp Ophthalmol 2013; 251:2609–2615.
2. Mathalone N, Hyams M, Neiman S, *et al.* Long-term intraocular pressure control after clear corneal phacoemulsification in glaucoma patients. J Cataract Refract Surg 2005; 31:479–483.
3. Poley BJ, Lindstrom RL, Samuelson TW, Schulze R. Intraocular pressure reduction after phacoemulsification with intraocular lens implantation in glaucomatous and nonglaucomatous eyes. Evaluation of a causal relationship between the natural lens and open-angle glaucoma. J Cataract Refract Surg 2009; 35:1946–1955.
4. Friedman DS, Jampel HD, Lubomski LH, *et al.* Article for CME credit surgical strategies for coexisting glaucoma and cataract an evidence-based update. Ophthalmology 2002; 109:1902–1915.
5. Gedde SJ, Schiffman JC, Feuer WJ, *et al.* Treatment outcomes in the tube versus trabeculectomy (TVT) study after five years of follow-up. Am J Ophthalmol 2012; 153:789–803; e2.
6. Saheb H, Ahmed IIK. Micro-invasive glaucoma surgery: current perspectives and future directions. Curr Opin Ophthalmol 2012; 23:96–104.
7. Gillmann K, Mansouri K. Minimally invasive glaucoma surgery: where is the evidence? Asia Pac J Ophthalmol (Phila) 2020; 9:203–214.
8. Musch DC, Gillespie BW, Niziol LM, *et al.* Cataract extraction in the Collaborative Initial Glaucoma Treatment Study incidence, risk factors, and the effect of cataract progression and extraction on clinical and quality-of-life outcomes.
9. Bellucci R, Perfetti S, Babighian S, *et al.* Filtration and complications after trabeculectomy and after phaco-trabeculectomy. Acta Ophthalmol Scand Suppl 1997; 44–45.
10. Park HJ, Weitzman M, Caprioli J. Temporal corneal phacoemulsification combined with superior trabeculectomy a retrospective case-control study SI NCE [Internet]. Arch Ophthalmol 1997; 115:318–323.
11. Murthy SK, Damji KF, Pan Y, Hodge WG. Trabeculectomy and phacotrabeculectomy, with mitomycin-C, show similar two-year target IOP outcomes. Can J Ophthalmol 2006; 41:51–59.
12. Amaral DC, Guedes J, de Oliveira Caneca K, *et al.* Manual small incision cataract surgery combined with trabeculectomy versus phacoemulsification combined with trabeculectomy for coexisting glaucoma and cataract: a systematic review and meta-analysis. Expert Rev Ophthalmol 2024; 19:281–289.
13. Ahmadzadeh A, Kessel L, Subhi Y, Bach-Holm D. Comparative Efficacy of Phacotrabeculectomy versus trabeculectomy with or without later phacoemulsification: a systematic review with meta-analyses. J Ophthalmol 2021; 2021:6682534.
14. Mathew RG, Parvizi S, Murdoch IE. Success of trabeculectomy surgery in relation to cataract surgery: 5-year outcomes. Br J Ophthalmol 2019; 103:1395–1400.
15. Chen PP, Weaver YK, Budenz DL, *et al.* Trabeculectomy function after cataract extraction. Ophthalmology 1998; 105:1928–1935.
16. Do AT, Parikh H, Panarelli JF. Subconjunctival microinvasive glaucoma surgeries: an update on the Xen gel stent and the PreserFlo MicroShunt. Curr Opin Ophthalmol 2020; 31:132–138.
17. ▪ Torbey J, Paillard A, Rao HL, *et al.* XEN 45 gel stent implantation in open angle glaucoma: 5-year results of a prospective study. J Glaucoma 2023; 32:909–917.

This is the first clinical trial presenting long term data on subjunctival MIGS. It shows that the XEN gel stent can provide effective IOP reduction up to 5 years.

18. Karimi A, Lindfield D, Turnbull A, *et al.* A multicentre interventional case series of 259 ab-interno Xen gel implants for glaucoma, with and without combined cataract surgery. Eye (Basingstoke) 2019; 33:469–477.
19. Martínez-de-la-Casa JM, Saenz-Francés F, Morales-Fernandez L, *et al.* Clinical outcomes of combined Preserflo Microshunt implantation and cataract surgery in open-angle glaucoma patients. Sci Rep 2021; 11:15600.
20. Batlle JF, Corona A, Albuquerque R. Long-term results of the PRESERFLO MicroShunt in patients with primary open-angle glaucoma from a single-center nonrandomized study. J Glaucoma 2021; 30:281–286.
21. Scheres LMJ, Kujovic-Aleksov S, Ramdas WD, *et al.* XEN® Gel Stent compared to PRESERFLO™ MicroShunt implantation for primary open-angle glaucoma: two-year results. Acta Ophthalmol 2021; 99:e433–e440.
22. Samuelson TW, Sarkisian SR, Lubeck DM, *et al.* Prospective, randomized, controlled pivotal trial of an ab interno implanted trabecular micro-bypass in primary open-angle glaucoma and cataract: two-year results. Ophthalmology 2019; 126:811–821.
23. Ahmed IIK, De Francesco T, Rhee D, *et al.* Long-term outcomes from the HORIZON randomized trial for a Schlemm's canal microstent in combination cataract and glaucoma surgery. Ophthalmology 2022; 129:742–751.
24. Falkenberry S, Singh IP, Crane CJ, *et al.* Excisional goniotomy vs trabecular microbypass stent implantation: a prospective randomized clinical trial in eyes with mild to moderate open-angle glaucoma. J Cataract Refract Surg 2020; 46:1165–1171.
25. Barkander A, Economou MA, Jóhannesson G. Kahook dual-blade goniotomy with and without phacoemulsification in medically uncontrolled glaucoma. Clin Ophthalmol 2023; 17:1385–1394.
26. Wagner IV, Towne C, Saade MC, *et al.* A review of canaloplasty in the treatment and management of glaucoma. J Curr Glaucoma Pract 2024; 18:79–85.
27. Dick HB, Mackert MJ, Ahmed IIK, *et al.* Two-year performance and safety results of the MINIject supraciliary implant in patients with primary open-angle glaucoma: meta-analysis of the STAR-I, II, III Trials. Am J Ophthalmol 2024; 260:172–181.
28. Feinberg L, Swampillai AJ, Byles D, Smith M. Six year outcomes of combined phacoemulsification surgery and endoscopic cyclophotocoagulation in refractory glaucoma. Graefes Arch Clin Exp Ophthalmol 2023; 261:1339–1347.
29. Sun W, Yu CY, Tong JP. A review of combined phacoemulsification and endoscopic cyclophotocoagulation: efficacy and safety. Int J Ophthalmol 2018; 11:1396–1402.
30. BOURNE R. Effect of cataract surgery on the corneal endothelium∗1Modern phacoemulsification compared with extracapsular cataract surgery. Ophthalmology 2004; 111:679–685.
31. Soro-Martínez MI, Miralles de Imperial-Ollero JA, Pastor-Montoro M, *et al.* Corneal endothelial cell loss after trabeculectomy and phacoemulsification in one or two steps: a prospective study. Eye (Basingstoke) 2021; 35:2999–3006.
32. Villegas-Pérez MP, Soro-Martínez MI, Sobrado-Calvo P, *et al.* Corneal endothelial cell loss after trabeculectomy or after phacoemulsification, IOL implantation and trabeculectomy in 1 or 2 steps. Graefes Arch Clin Exp Ophthalmol 2010; 248:249–256.
33. Olgun A, Duzgun E, Yildiz AM, *et al.* XEN Gel Stent versus trabeculectomy: short-term effects on corneal endothelial cells. Eur J Ophthalmol 2021; 31:346–353.
34. Gillmann K, Bravetti GE, Rao HL, *et al.* Impact of phacoemulsification combined with XEN gel stent implantation on corneal endothelial cell density: 2-year results. J Glaucoma 2020; 29:155–160.
35. Gassel CJ, Wenzel DA, Nasyrov E, *et al.* Intermediate-term impact on corneal endothelial cells and efficacy of Preserflo MicroShunt implantation in patients with open-angle glaucoma – a prospective study over two years. Graefes Arch Clin Exp Ophthalmol 2024.
36. Ibarz-Barberá M, Morales-Fernández L, Corroto-Cuadrado A, *et al.* Corneal endothelial cell loss after PRESERFLOTM MicroShunt implantation in the anterior chamber: anterior segment OCT tube location as a risk factor. Ophthalmol Ther 2022; 11:293–310.
37. Dorairaj S, Balasubramani GK. Corneal endothelial cell changes after phacoemulsification combined with excisional goniotomy with the kahook dual blade or istent: a prospective fellow-eye comparison. Clin Ophthalmol 2020; 14:4047–4053.
38. Fang CEH, Mathew RG, Khaw PT, Henein C. Corneal endothelial cell density loss after glaucoma surgery alone or in combination with cataract surgery. Ophthalmology 2022; 129:841–855.
39. Manoharan N, Patnaik JL, Bonnell LN, *et al.* Refractive outcomes of phacoemulsification cataract surgery in glaucoma patients. J Cataract Refract Surg 2018; 44:348–354.
40. Seo S, Lee CE, Kim YK, *et al.* Factors affecting refractive outcome after cataract surgery in primary angle-closure glaucoma. Clin Exp Ophthalmol 2016; 44:693–700.

41. Ong C, Nongpiur M, Peter L, Perera SA. Combined approach to phacoemulsification and trabeculectomy results in less ideal refractive outcomes compared with the sequential approach. J Glaucoma 2016; 25: e873–e878.
42. Kook MS, Kim HB, Lee SU. Short-term effect of mitomycin-C augmented trabeculectomy on axial length and corneal astigmatism. J Cataract Refract Surg 2001; 27:518–523; 2001.
43. Tzu JH, Shah CT, Galor A, *et al.* Refractive outcomes of combined cataract and glaucoma surgery. J Glaucoma 2015; 24:161–164.
44. Muallem MS, Nelson GA, Osmanovic S, *et al.* Predicted refraction versus refraction outcome in cataract surgery after trabeculectomy. J Glaucoma 2009; 18:284–287.
45. Bae HW, Lee YH, Kim DW, *et al.* Effect of trabeculectomy on the accuracy of intraocular lens calculations in patients with open-angle glaucoma. Clin Exp Ophthalmol 2016; 44:465–471.
46. Shaheen A, Afflitto GG, Swaminathan SS. Refractive outcomes following combined cataract and microinvasive glaucoma surgery. Ophthalmol Glaucoma 2024.
47. Tatti F, Tronci C, Lixi F, *et al.* No changes in keratometry readings and anterior chamber depth after XEN gel implantation in patients with glaucoma. J Clin Med 2024; 13:2537.
48. Ibarz Barberá M, Morales-Fernandez L, Gómez de Liaño R, *et al.* Changes to corneal topography and biometrics after PRESERFLO microshunt surgery for glaucoma. J Glaucoma 2021; 30:921–931.
49. Ioannidis AS, Töteberg-Harms M, Hamann T, Hodge C. Refractive outcomes after trabecular micro-bypass stents (Istent inject) with cataract extraction in open-angle glaucoma. Clin Ophthalmol 2020; 14:517–524.
50. Scott RA, Ferguson TJ, Stephens JD, Berdahl JP. Refractive outcomes after trabecular microbypass stent with cataract extraction in open-angle glaucoma. Clin Ophthalmol 2019; 13:1331–1340.
51. Ang BCH, Chen EJ, Chee WK, *et al.* Combined phacoemulsification and hydrus microstent implantation in Asian eyes with moderate-to-severe normal tension glaucoma – 12-month outcomes. J Glaucoma 2024.
52. Sieck EG, Capitena Young CE, Epstein RS, *et al.* Refractive outcomes among glaucoma patients undergoing phacoemulsification cataract extraction with and without Kahook Dual Blade goniotomy. Eye Vis (Lond) 2019; 6:28.
53. Sheybani A, Saboori M, Kim JM, *et al.* Effect of endoscopic cyclophotocoagulation on refractive outcomes when combined with cataract surgery. Can J Ophthalmol 2015; 50:197–201.
54. Wang JCC, Campos-Möller X, Shah M, *et al.* Effect of endocyclophotocoagulation on refractive outcomes in angle-closure eyes after phacoemulsification and posterior chamber intraocular lens implantation. J Cataract Refract Surg 2016; 42:132–137.
55. Ichhpujani P, Bhartiya S, Sharma A. Premium IOLs in glaucoma. J Curr Glaucoma Pract 2013; 7:54–57.
56. Fili S, Kontopoulou K, Vastardis I, *et al.* PreserFlo™ microshunt combined with phacoemulsification versus preserflo™ MicroShunt as a standalone procedure in patients with medically resistant open-angle glaucoma. J Curr Ophthalmol 2022; 34:180–186.
57. ▪ Dick HB, Mackert MJ, Ahmed IIK, *et al.* Two-year performance and safety results of the MINIject supraciliary implant in patients with primary open-angle glaucoma. Am J Ophthalmol 2024; 260:172–181.
This study presents 2-year data from a meta-analysis of three pivotal trials of the MINIject suprachoroidal implant.