Drugs & Aging (2026) 43:153–162
https://doi.org/10.1007/s40266-025-01271-9

REVIEW ARTICLE

Implants to Treat Glaucoma: Promising or Not?

Barbara Cvenkel[1,2] · **Miriam Kolko**[3,4,5,6]

Received: 9 August 2025 / Accepted: 18 November 2025 / Published online: 31 December 2025

Abstract

Glaucoma is one of the leading causes of blindness and its prevalence increases with age. The most common form, primary open-angle glaucoma, is a chronic, slowly progressive optic neuropathy characterised by the loss of retinal ganglion cells and their axons, leading to irreversible visual field loss. Elevated intraocular pressure (IOP) is the only modifiable risk factor for glaucoma. Reducing IOP to a level that is safe for the patient's eye has been shown to slow disease progression. Lowering IOP in open-angle glaucoma is achieved by eye drops, selective laser trabeculoplasty (SLT) and/or surgery. Many patients are treated with IOP-lowering eye drops, which require lifelong continuous instillation. However, as with other chronic, asymptomatic diseases, adherence to glaucoma treatment is poor for various reasons and is associated with faster disease progression. The purpose of this review is to discuss several sustained-release systems that have been investigated to reduce IOP over time, to address barriers to adherence and improve quality of life. Among these, non-invasive drug-eluting delivery systems such as contact lenses, punctal plugs, and conjunctival ocular inserts have not reached the market. Currently, only two intracameral implants have been approved by the Food and Drug Administration for single use due to corneal safety issues. The biodegradable bimatoprost implant releases the drug continuously for 4–6 months, and its effect on IOP may extend for up to 2 years in 25% of patients. The non-biodegradable intracameral implant releases travoprost for 36 months, when it needs to be removed. However, additional data are needed to assess safety following repeated administration, as well as in broader patient populations and in combination with other treatment approaches such as SLT. Several other biodegradable intracameral implants that release prostaglandin analogues are undergoing clinical trials. In the future, intraocular implants containing genetically modified cells that secrete neurotrophic factors may potentially offer an IOP-independent neuroprotective strategy, complementing existing IOP-lowering implants in glaucoma management.

Key Points

In patients with open-angle glaucoma, lowering intraocular pressure (IOP) to a safe level (target IOP) for an individual eye to preserve visual function can be achieved with IOP-lowering eye drops, laser trabeculoplasty, or surgery. Many patients require lifelong use of eye drops, a regimen often perceived as burdensome and affecting quality of life, independent of the disease's severity.

Sustained drug-releasing implants can address the challenge of poor adherence, but only two intracameral implants, one releasing bimatoprost and the other travoprost, have been approved by the Food and Drug Administration for single administration.

Drug-eluting implants may hold promise for the future, but more information needs to be provided on their safety, cost effectiveness and use in a broader patient population.

✉ Barbara Cvenkel
barbara.cvenkel@mf.uni-lj.si

1 Department of Ophthalmology, University Medical Centre Ljubljana, Grabloviceva 46, 1000 Ljubljana, Slovenia

2 Faculty of Medicine, University of Ljubljana, Vrazov trg 2, 1000 Ljubljana, Slovenia

3 Department of Drug Design and Pharmacology, University of Copenhagen, Copenhagen, Denmark

4 Department of Ophthalmology, Copenhagen University Hospital, Rigshospitalet, Glostrup, Denmark

5 Department of Ophthalmology, Aalborg University Hospital, Aalborg, Denmark

6 Eye Hospital, Your Eye Doctors (Dine Øjenlæger), Sundhedshuset, Rungsted Kyst, Denmark

1 Introduction

Glaucoma is one of the most common causes of irreversible blindness worldwide, which can be prevented by timely diagnosis and treatment. It is characterised by a progressive loss of retinal nerve fibres and the corresponding retinal ganglion cells of the optic nerve, which leads to visual field loss and, if left untreated, to visual impairment and blindness in some patients. The worldwide prevalence of the most common form of primary open-angle glaucoma (POAG) for the population over 40 years of age is estimated at 2.2% [1] and increases with age [2, 3]. The estimated prevalence of POAG depends on ethnicity, being 0.4% in the White population and 2.1% in the Black population at the age of 40 years, increasing to 7.3 and 14.9%, respectively, at the age of 85 years [2]. As the proportion of older people in the population increases, there will be more patients with glaucoma who need treatment to prevent the disease from progressing to visual impairment and affecting their quality of life [4]. The asymptomatic progression of the disease to the advanced stage of optic nerve damage is the main reason for late detection [5, 6]. Treatment of glaucoma focuses on lowering intraocular pressure (IOP), which is currently the only evidence-based modifiable risk factor [7, 8]. Lowering IOP to a level that is safe for the individual patient's eye (target IOP) slows the progression of glaucoma [8, 9]. Setting the target IOP at diagnosis depends on the extent of glaucoma damage, life expectancy, untreated IOP, and the presence of additional risk factors (such as family history or the status of the other eye) [10]. In younger patients with advanced disease, the target IOP should be set lower [11]. In POAG, it is recommended to initiate treatment with eye drops containing prostaglandin analogues (monotherapy) or selective laser trabeculoplasty (SLT) [10, 12]. However, when the target IOP cannot be achieved and there is clinically significant disease progression that will lead to visual impairment during the patient's lifetime, surgery is required [10]. In early to moderate glaucoma, minimally invasive glaucoma surgery, often combined with cataract surgery, can reduce the number of eye drops needed for IOP control [13–15]. Eye drops lower IOP by increasing aqueous humour outflow and/or decreasing aqueous production [16]. As glaucoma is a chronic disease, patients usually must take their medication for the rest of their lives. Reported rates of non-adherence to topical glaucoma medication vary widely from 16 to 67% due to different methods of determining non-adherence as well as the lack of a quantitative standard to measure adherence to glaucoma medication [17]. Adherence over a longer period is even lower. In Taiwan, for example, only a quarter of patients with newly diagnosed glaucoma continued their glaucoma medication after 2 years of follow-up [18], while in another study, only 15% with newly diagnosed glaucoma showed sustained good adherence over 4 years of follow-up [19]. A recent study, however, demonstrated that good adherence during the first year is predictive of sustained long-term adherence, enabling the identification and stratification of patients at risk for poor adherence [20]. The main barriers associated with non-adherence to treatment include forgetfulness, low self-efficacy, difficulties with instillation of drops and treatment schedule, medication side effects, lack of motivation and poor education [19, 21]. It is known that poorer adherence to glaucoma treatment leads to higher IOP, greater fluctuations in IOP and consequently progression of glaucoma [22–24]. In the longitudinal Collaborative Initial Glaucoma Treatment Study, patients who reported missing more doses of medication at visits showed faster visual field progression over 7.3 years [25].

To improve treatment adherence, several strategies have been used to target various barriers [26]. These include education and awareness of the disease, reminders, various drug delivery systems, reducing the side effects of topical medications by prescribing well-tolerated preservative-free eye drops, performing SLT, minimally invasive glaucoma surgery in combination with cataract surgery to reduce the number of eye drops, and implants that reduce IOP in the long term and do not depend on the patient's adherence to medication [27].

This narrative review focuses on the various systems for sustained IOP reduction, including intracameral implants, contact lenses, punctal plugs and ocular inserts. Intraocular implants targeting retinal ganglion cell neuroprotection appear to be a promising approach for the future. We conducted a literature search using the PubMed database. The following search terms were used: 'drug delivery systems' AND 'glaucoma treatment', 'adherence' AND 'glaucoma', and 'intraocular implants' AND 'glaucoma'. We included articles in English published before July 2025, including clinical trials in humans, editorials, reviews, systematic reviews, and meta-analyses. After retrieving relevant articles using these keywords, we reviewed the reference lists of the selected studies and identified additional papers.

2 Sustained Drug Delivery Systems Reducing Intraocular Pressure

2.1 Intracameral Implants

Sustained release drug delivery reduces the burden of adherence to medication, increases delivery to target tissues of the trabecular meshwork and ciliary body with fewer potential side effects on the ocular surface. Different platforms, biodegradable or non-biodegradable, can be used to allow controlled release of the drug. Currently, only two

sustained-release intracameral implants are available for single administration, while many intracameral implants are still in various stages of clinical trials.

2.1.1 Bimatoprost Sustained-Release Intracameral Implant (Durysta; Allergan, an AbbVie company, North Chicago, IL, USA)

The bimatoprost sustained-release (BmSR) intracameral implant is a biodegradable implant containing bimatoprost 10 µg which is released continuously over 4–6 months. In March 2020, the BmSR implant was the first Food and Drug Administration (FDA)-approved intracameral implant to reduce IOP for the treatment of open-angle glaucoma and ocular hypertension [28]. It is a rod-shaped implant with a diameter of approximately 200 µm and a length of 1.1 mm that delivers medication using the Novadur® drug delivery system, which contains a polymer matrix of poly-D,L-containing lactide-co-glycolide that degrades to lactic acid and glycolic acid [29]. This platform has been used since 2009 for the slow release of dexamethasone for the treatment of macular oedema in other eye diseases. The implant is injected with a sterile single-use 28-gauge applicator under aseptic conditions at the slit lamp or in the operating theatre. The most frequently reported adverse event was conjunctival hyperaemia related to the procedure. The treatment is approved for single administration only, due to the risk of corneal endothelial cell loss with repeated administration [30]. The BmSR implant has not been approved by the European Medicines Agency (EMA). AbbVie withdrew the application for marketing authorisation of Durysta in September 2024 because the major objections raised by the EMA could not be resolved within the available time frame [31]. In particular, the EMA considered the safety profile of Durysta unacceptable due to the increased occurrence of irreversible corneal endothelial cell loss and poor biodegradation of the implant, which was still visible 24 months post-implantation in a large proportion of patients [32].

Bimatoprost is a prostaglandin analogue and prostamide that, when administered topically, lowers IOP by increasing the outflow of aqueous humour through both the trabecular meshwork and the uveoscleral pathway [33]. In clinical trials, BmSR implant with a dosage of 10 µg showed best efficacy and safety profiles with mean IOP reduction from baseline ranging from 7.4 to 9.7 mmHg, which was non-inferior to timolol twice daily [30, 34]. The in-vitro study showed complete drug release within 90 days, and drug concentrations were below the detection limit (<0.05 ng/ml) in the aqueous humour samples from two patients taken 3–4 months after the last implant administration [30]. Interestingly, in phase I/II clinical trials (ClinicalTrials.gov identifier: NCT01157364), the IOP-lowering effect of the BmSR implant persisted in 28% of patients for up to 2 years after a single administration [35]. Such a prolonged response in some patients may be due to the variability of matrix metalloproteinase upregulation stimulated by bimatoprost at high concentrations, which promotes sustained outflow tissue remodelling and long-term pressure reduction beyond the bioavailability of the drug [36].

Real-world retrospective studies in small patient groups showed a reduction in medication burden, effective IOP reduction and an adequate safety profile in a broader patient population, including patients with previous glaucoma surgery, different types of glaucoma and certain populations not included in the clinical trials [37–40]. The BmSR implant was statistically and clinically non-inferior to SLT in lowering intraocular pressure over 24 months [41].

2.1.2 Travoprost Intracameral Implant (iDose® TR; Glaukos Corporation, Aliso Viejo, California, USA)

Travoprost 75 µm slow-eluting intracameral implant received FDA approval for single administration in December 2023 [42]. The implant is made of titanium, has a length of 1.84 mm and an outer diameter of 0.49 mm and slowly releases travoprost through a thin membrane over 36 months [43]. The implant is preloaded in a disposable inserter, which the surgeon advances across the anterior chamber to anchor the implant through the trabecular meshwork in the scleral wall [44]. When the drug reservoir is depleted, it needs to be removed.

Travoprost is a prostaglandin analogue that binds strongly to the prostaglandin receptors F2α and, when administered topically, lowers IOP by increasing the outflow of aqueous humour through the uveoscleral and trabecular meshwork pathways [33]. Travoprost, administered once daily, effectively lowers intraocular pressure in the range of 6.6–9.0 mmHg in most studies [45].

The long-term efficacy and safety of the slow-eluting (SE) and fast-eluting (FE) travoprost implants showed an effective reduction in IOP over 36 months after a single administration, comparable to twice-daily administration of timolol with a favourable safety profile [43]. At 12, 24 and 36 months, a greater proportion of patients with travoprost implants were well controlled compared with timolol patients on the same or fewer IOP-lowering drugs [43].

In a clinical phase III study (NCT03519386), the SE travoprost implant (iDose® TR) achieved a significant and clinically relevant reduction in IOP that was not inferior to twice-daily timolol [46]. In this study, of the patients taking glaucoma medications at the time of the study, 83.5% of patients in the SE travoprost implant group versus only 23.9% of patients in the timolol group were well controlled at month 12 [46]. A pooled analysis of two phase III studies (NCT03519386; NCT03868124) evaluating the safety and

efficacy of SE and FE travoprost implants (a total of 1150 subjects treated with FE implant [385 patients], SE implants [380 patients] and sham/timolol [385 patients]) showed statistical non-inferiority to timolol and clinically relevant reductions at month 12, with more patients completely free of topical medication in the implants groups versus sham/timolol group [47]. Adverse events were mostly mild and transient and related to the administration procedure, including iritis (5%) and ocular hyperaemia (2%), while serious adverse events included two increased intraocular pressures, one retinal detachment and one endophthalmitis in four patients [43, 48]. In addition, the travoprost implant produced a greater reduction in IOP than topical prostaglandin analogue monotherapy in subjects prior to the study, presumably due to better adherence of patients with an implant [49].

In a retrospective study of consecutive patients with glaucoma, travoprost implant (iDose® TR) was used in 65 pseudophakic eyes, of which 54 eyes, the majority (74%), had mild glaucoma [44]. Three months after surgery, the mean IOP had been reduced by 33.2%, with a significant increase in the proportion of patients achieving lower IOP thresholds. There were no intraoperative complications, one eye had mild iritis, which resolved after topical corticosteroid therapy [44]. Recently, the intracameral travoprost implant, administered in conjunction with cataract surgery, was shown to be safe and achieved an average intraocular pressure (IOP) reduction of 10.6 mmHg at 3 months postoperatively [50].

2.1.3 Other Intracameral Implants in Clinical Trials

ENV515 (Envisia Therapeutics, Durham, NC, USA) is a biodegradable nanotechnology polymer drug delivery system that uses particle replication in a non-wetting technology and enables extended release of travoprost over 6 months. The polymer is printed, filled with travoprost and injected into the anterior chamber. In the open-label phase IIa study (NCT02371746), IOP was reduced by 6.7 mmHg (28%) on day 25 in one group, which was comparable to once-daily administration of travoprost ophthalmic solution 0.004% (Alcon) in the fellow eye. The 3-month interim results showed that the implant was well tolerated, and no serious adverse events occurred. The low-dose form of ENV5151 was planned for a 12-month safety and efficacy study (NCT02371746) [51]. The results have not yet been reported.

The travoprost implant OTX-TIC (Paxtrava™, Ocular Therapeutix, Bedford, MA, USA) is a biodegradable implant using travoprost (26 µg)-loaded microparticles embedded in hydrogel. The implant is administered into the anterior chamber of the eye with a 26-gauge needle and is released over 6 months. In a phase II study (NCT05335122), the intracameral Travoprost OTX-TIC implant achieved a similar reduction in IOP (24–30% from baseline) as the bimatoprost implant (Durysta) over 6 months. The reported adverse events were of low severity and mostly related to the injection procedure [52].

PA5108 Latanoprost free acid sustained-release ocular implant (Polyactiva, Melbourne, Australia) is a biodegradable implant that is inserted into the anterior chamber with a 27-gauge needle and releases latanoprost over 6 months. A phase II study is comparing the efficacy and safety of low and high dose ocular implants with latanoprost drops in the fellow eye over 53 weeks (NCT06964191).

2.2 Other Sustained Drug Delivery Systems

2.2.1 Punctal Plugs

Punctal plugs are made of polymeric material and can vary in shape and structural features, such as the core (polymer matrix or drug matrix that is permeable to tear fluid), the cap (semi-permeable or impermeable membrane with pores), the body (impermeable to drugs and tear fluid) and the nose (aid for inserting the plug). They are inserted into one or both puncta of each eye [53]. An important limitation of the punctal plug delivery systems is that they can only deliver low doses of the potent drugs typically required, such as prostaglandins [53].

The Latanoprost Punctal Plug Delivery System (Mati Therapeutics, Austin, Tx, USA) consists of a core of latanoprost polymer matrix surrounded by non-biodegradable silicone. In a phase II study (NCT01229982), the plugs were inserted into the upper and lower puncta of 95 subjects, with a combined latanoprost dose of 141 µg. After 4 weeks, mean IOP had statistically decreased by 5.7 mmHg from baseline, with 60% of subjects achieving a reduction of 5 mmHg or more. The most commonly reported adverse events were lacrimation and mild discomfort associated with the punctal plugs [54].

The travoprost punctal plug (OTX-TP, Ocular Therapeutix, Inc. Bedford, MA, USA) consists of travoprost encapsulated in polylactic acid microparticles suspended in a resorbable polyethylene glycol hydrogel rod. After insertion, the hydrogel rod swells and gradually releases travoprost from the inner microsphere matrix over a period of 90 days. The reduction in IOP was less than in the timolol eye drop group. The retention rate decreased to 42% by month 1. Side effects reported included discomfort, lacrimation and canaliculitis. There are no ongoing clinical trials with travoprost punctal plugs [55, 56].

2.2.2 Ocular Inserts

The ocular inserts are shaped to fit into the conjunctival fornix and allow the drug to be released over a prolonged period. They are not available on the market.

Pilocarpine ocular insert (Ocusert, Alza Corp., Palo Alto, California, USA), introduced in the early 1970s, was the first pilocarpine delivery system that was inserted into the conjunctival fornix once weekly and produced a comparable reduction in intraocular pressure to pilocarpine eye drops [57]. It was withdrawn from the market in 1993, although it was well tolerated by the eyes.

Bimatoprost sustained ocular insert (AbbVie; Allergan) consists of an inner polypropylene ring with a preservative-free silicone matrix impregnated with bimatoprost 13 mg.

The ring is inserted into the fornices and is designed to remain in place for 6 months. In the 6-month phase II study (NCT01915940), the bimatoprost ring achieved a mean reduction in IOP from −3.2 to −6.4 mmHg with a good primary retention rate of the insert in 88.5% of patients over 6 months [58]. In the 13-month open-label extension study (NCT02143843), the bimatoprost ring was safe and well tolerated and remained in place in 95% of patients during the 13-month extension period. The most common adverse events were bimatoprost-related and of low severity and included conjunctival hyperaemia, ocular discharge, punctate keratitis, lacrimation, foreign body sensation and discomfort [59].

2.2.3 Contact Lenses

The medication released by the contact lens into the tear film is retained in front of the cornea, which increases the residence time compared with eye drops from about 2 minutes to 30 minutes [60]. This longer retention time can lead to a higher bioavailability of the medication. Although research has been ongoing for many years, there are currently no approved products utilising this delivery system [61].

Contact lens-based delivery systems can incorporate the drug into the lens in a variety of configurations, including coating or embedding a drug-polymer film into the contact lens, molecular imprinting the drug into a polymeric hydrogel, surface adsorption of nano-carriers or drugs in the contact lens with hydrogel, dispersion of nanoparticles, liposomes or emulsions in the hydrogel of the contact lens, dispersion of surfactant-drug complexes in the lens, and adsorption of the drug to preformed contact lens material by soaking [62]. Contact lenses loaded with timolol, brimonidine and latanoprost with a drug release of up to 1 month have been investigated [63]. The main challenge is still to achieve prolonged drug release from contact lenses. Superficial impregnation of contact lenses with medication and the incorporation of vitamin E as a diffusion barrier as well as drug-loaded liposomes and micelles could also be an alternative to prolong drug release. Further research is needed to determine the efficacy, safety and comfort of contact lenses [53].

2.2.4 Subconjunctival Drug Delivery

The latanoprost implant (Eye-D VS-101 insert; BioLight Life Sciences, Israel), is designed to release latanoprost over 12 months. In the phase I/IIa clinical trial (NCT02129673), the latanoprost implant was inserted into the subconjunctival space through an in-office surgical procedure. Eye-D Latanoprost Insert produced a 24% reduction in mean daily IOP from baseline over 24 weeks and had a favourable safety profile [64]. No further results are available.

Biodegradable nanoparticles and liposomes for prolonged drug release (latanoprost, brimonidine, timolol) are being investigated. Subconjunctival application of liposomal latanoprost reduced IOP over 3 months (NCT01987323) [56, 65].

2.2.5 Intraocular Lens Implant Delivery (Spyglass System)

The SpyGlass System (SpyGlass Pharma, Aliso Viejo, California, USA) is an innovative device developed for use in cataract extraction and intraocular lens implantation. Drug-releasing pads are attached to the optic-haptic junction of a hydrophobic single-piece intraocular lens [66]. The intraocular lens together with the drug-eluting pads is inserted into the capsular bag through a standard 2.4-mm corneal incision. The drug-eluting pads are positioned outside the visual axis and slowly release medication for up to 3 years. A study of 23 patients with glaucoma or ocular hypertension who received the SpyGlass intraocular lens (IOL)-based drug delivery platform with bimatoprost during cataract surgery showed an average 45% reduction in IOP from baseline at the 9-month follow-up, with 100% of eyes maintaining an IOP of ≤18 mmHg and experiencing more than a 20% IOP reduction from baseline. All eyes remained free of additional IOP-lowering medications throughout the study period. Adverse events were rare and mild and were not related to the investigational product [67]. A phase I/II study (NCT06120842) in the United States is planned to further evaluate efficacy and safety in a larger cohort of patients.

3 Advantages and Limitations of Implants and Drug Delivery Systems

Drug delivery systems reduce the need for daily instillation of eye drops and the burden of adherence. In a semi-structured interview about glaucoma treatment, expectations of treatment, the impact on their lives and daily activities,

glaucoma patients expressed that glaucoma treatment is a burden that is different from the burden of the disease process itself, and that this burden affects their quality of life [68]. For patients with varying degrees of glaucoma severity, the outcomes of both the disease and its treatment are important [69]. Questionnaires were recently used to investigate awareness and acceptance of ocular drug delivery devices in 102 glaucoma patients [70]. The survey found that these devices would potentially be widely accepted and favoured by glaucoma patients over eye drops, particularly in patients severely affected by their disease. Contact lenses, punctal plugs and drug-eluting stents appear to be favoured over anterior chamber injections or subconjunctival implants. The most important factors in the decision to use an ocular delivery device were efficacy and long-lasting effect.

Intraocular implants that deliver drug directly to target tissues can reduce side effects. For instance, intracameral prostaglandin implants have been associated with only mild adverse effects, primarily related to the administration procedure itself. Notably, common side effects seen with prostaglandin eye drops, such as iris hyperpigmentation and eyelash growth, were not observed in patients treated with the bimatoprost implant [35, 71].

Glaucoma is a chronic disease and usually requires lifelong treatment. Currently, the two available intracameral implants are only approved by the FDA for single use due to safety issues. The travoprost implant is not degradable, and if the drug is depleted, the implant must be removed and re-administered. The average amount of travoprost remaining in explanted travoprost implants (iDose TR) was 79% at 3 months, 70% at 6 months, 50% at 12 months, 39% at 15 months, 35% at 18 months, 28% at 21 months and 16% at 24 months, demonstrating the potential for effective drug delivery beyond 2 years [72].

The biodegradation of the bimatoprost implant can vary from patient to patient, and over time, when the drug is released, the implant is still present and continues to degrade [73]. None of the studies looked at the optimal time to administer a second bimatoprost implant after the effects of the first implant have worn off. More real-world data with a broader patient population (different types and severities of glaucoma, after glaucoma surgery, in combination with other IOP-lowering therapies such as SLT or minimally invasive glaucoma surgery) with longer follow-up are needed to gain insights into the safety and efficacy of the implant [37].

Intraocular injections are an invasive procedure that carries the risk of endophthalmitis and potentially the risk of hypersensitivity reactions. Finally, there are no cost-effectiveness studies comparing the implants with conventional therapies in the long-term treatment of glaucoma [37].

4 Future Horizon/Neuroprotection and Neuroenhancement

All current medical and surgical treatments are aimed at reducing IOP. In many patients, the disease progresses despite apparently controlled IOP. Therefore, strategies that target the neurodegenerative process itself by improving the survival, resilience and regeneration of retinal ganglion cells are an important treatment goal.

Ciliary neurotrophic factor (CNTF) is a protein that belongs to the interleukin (IL)-6 family of cytokines and plays an important role in the survival, growth and regeneration of neurons and their axons [74]. In animal models, continuous delivery of CNTF has a protective effect on retinal neurons, slowing the progression of photoreceptor degeneration and preserving retinal function [75–77]. Long-term retinal neuroprotection has been documented using encapsulated cells genetically engineered to produce a stable source of CNTF. Recently, this CNTF-secreted encapsulated cell technology (ECT) NT-501 (ENCELTO, Neurotech Pharmaceuticals, Inc. Cumberland, Rhode Island, USA) has received FDA approval for the treatment of macular telangiectasia type 2 [78]. The device measures 1 mm in diameter and 6 mm in length. It consists of an inner matrix framework and an outer semi-permeable membrane with a titanium anchor at one end. Each implant contains approximately 200,000 encapsulated cells from human retinal pigment epithelium that have been genetically engineered to secrete human CNTF at a high dose of 20 ng per day [79]. The implant is inserted into the eye through the pars plana 3.75 mm behind the limbus in the inferotemporal quadrant and secured with a 9-0 prolene suture. The safety and efficacy of the NT-501 CNTF implant was evaluated in a phase I clinical trial (NCT01408472) in 11 patients with primary open-angle glaucoma who were followed for 18 months [79]. The implant was placed in one eye of each patient and the other eye served as a control eye. The implant was safe, adverse events were related to the insertion of the implant and had completely resolved 12 weeks after the procedure. The eyes with the implant showed an improvement in both structural (retinal nerve fibre layer thickness measured by optical coherence tomography and scanning laser polarimetry with variable corneal compensation) and functional parameters (visual acuity, contrast sensitivity, visual field) compared with the other control eyes [79]. A randomised, sham-controlled, masked, phase II clinical trial with a single or second implantation after 12 months is underway (NCT02862938, NCT04577300). Table 1 lists sustained drug delivery systems, focused on lowering IOP and providing neuroprotection or neuroregeneration, which are at various stages of clinical development.

Table 1 Sustained drug delivery systems approved and at various developmental stages for the treatment of glaucoma

Delivery system	Product name	Developer	Active agent	Route of administration	Duration of action	Development stage
Reducing intraocular pressure						
Intracameral implants	Durysta	Allergan, North Chicago, IL, USA	Bimatoprost	Biodegradable intracameral implant	4–6 months	FDA approved
	iDose TR	Glaukos, Aliso Viejo, CA, USA	Travoprost	Non-degradable implant	Up to 36 months	FDA approved
	ENV515	Envisia Therapeutics, Durham, NC, USA	Travoprost	Biodegradable intracameral implant	4–6 months	Phase III NCT02371746
	Paxtrava	Ocular Therapeutix, Bedford, MA, USA	Travoprost	Biodegradable intracameral implant	6 months	Phase II NCT05335122
	PA5108	Polyactiva, Melbourne, Australia	Latanoprost	Biodegradable intracameral implant	6 months	Phase II NCT06964191
Punctal plugs	Evolute	Mati Therapeutics, Austin, TX, USA	Latanoprost	Punctum	1 month or longer	Phase II completed NCT03318146
	OTX-TP—development discontinued	Ocular Therapeutix Inc., Bedford, MA, USA	Travoprost	Punctum	Up to 3 months	Phase III NCT02914509; NCT01845038
External ocular inserts	Bimatoprost ocular ring	Allergan, North Chicago, IL, USA	Bimatoprost	Nondegradable ring inserted into the conjunctival fornices	Up to 6 months	Phase II NCT01915940 NCT02143843
Contact lenses		Various developers	Timolol Latanoprost Brimonidine	Ocular surface	1 month	Preclinical
Subconjunctival injection	Eye-D VS-101	BioLight Life Sciences, Israel	Latanoprost	Subconjunctival insert	Up to 12 months	Phase I/IIa NCT02129673
	Liposomal latanoprost	Singapore Eye Research Institute	Latanoprost	Subconjunctival injection of liposomal latanoprost	Up to 3 months	Phase I Phase II NCT01987323
Intraocular lens implant	SpyGlass System	SpyGlass Pharma, Aliso Viejo, CA, USA	Bimatoprost	IOL pads eluting bimatoprost	Up to 3 years	Phase I/II NCT06120842
Neuroprotection/neuroregeneration						
Intraocular implant—encapsulated cell technology	ENCELTO	Neurotech Pharmaceuticals, Inc., Cumberland, RI, USA	CNTF	Nondegradable implant inserted and sutured behind the limbus, genetically modified RPE cells secrete CNTF	Neuroprotection and neuroregeneration of retinal ganglion cells	Phase II NCT02862938

CNTF ciliary neurotrophic factor, *FDA* Food and Drug Administration, *IOL* intraocular lens, *RPE* retinal pigment epithelium

5 Conclusions

Adherence to glaucoma medication is a burden for patients that affects their daily activities and quality of life, regardless of the severity of the disease itself. Reducing the burden of correct and long-term regular instillation of eye drops by introducing effective, sustainable and safe delivery systems would be of great benefit to both patients and clinicians. Although patients prefer non-invasive drug delivery systems, such as contact lenses, these are not available for the treatment of glaucoma. Implants that release prostaglandin analogues in a controlled manner over longer periods of time are currently more promising. However, there are safety issues with repeated injections or removal of the non-degradable implants when the drug is released. In many glaucoma patients, particularly those with advanced glaucoma, several

classes of medication are required to reduce IOP to a safe level and prevent disease progression. In these patients, an implant that releases only one class of medication cannot be expected to achieve the target IOP without additional therapy.

Funding None provided.

Declarations

Conflict of interest Barbara Cvenkel has received fees unrelated to the present publication for serving on an advisory board from Théa Laboratories and lecturing fees from Théa Laboratories and Santen. Miriam Kolko has received fees unrelated to the present publication as a speaker for AbbVie, Santen, Théa Laboratories, and Topcon; and sits on advisory boards for AbbVie, Santen, and Théa Laboratories.

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Availability of data and materials Not applicable.

Code availability Not applicable.

Author contributions B.C. and M.K. drafted the first version of the manuscript; B.C. and M.K. contributed to the study concept and design and supervised the writing. Both authors discussed and commented on the manuscript and approved the final version.

References

1. Kapetanakis VV, Chan MP, Foster PJ, Cook DG, Owen CG, Rudnicka AR. Global variations and time trends in the prevalence of primary open angle glaucoma (POAG): a systematic review and meta-analysis. Br J Ophthalmol. 2016;100(1):86–93.
2. Tham YC, Li X, Wong TY, Quigley HA, Aung T, Cheng CY. Global prevalence of glaucoma and projections of glaucoma burden through 2040: a systematic review and meta-analysis. Ophthalmology. 2014;121(11):2081–90.
3. Jayaram H, Kolko M, Friedman DS, Gazzard G. Glaucoma: now and beyond. Lancet. 2023;402(10414):1788–801. https://doi.org/10.1016/S0140-6736(23)01289-8.
4. Latif K, Nishida T, Moghimi S, Weinreb RN. Quality of life in glaucoma. Graefes Arch Clin Exp Ophthalmol. 2023;261(10):3023–30.
5. Susanna R Jr., De Moraes CG, Cioffi GA, Ritch R. Why do people (still) go blind from glaucoma? Transl Vis Sci Technol. 2015;4(2):1. https://doi.org/10.1167/tvst.4.2.1.
6. Topouzis F, Coleman AL, Harris A, Koskosas A, Founti P, Gong G, et al. Factors associated with undiagnosed open-angle glaucoma: the Thessaloniki Eye Study. Am J Ophthalmol. 2008;145(2):327–35.
7. Heijl A, Leske MC, Bengtsson B, Hyman L, Bengtsson B, Hussein M. Reduction of intraocular pressure and glaucoma progression: results from the Early Manifest Glaucoma Trial. Arch Ophthalmol. 2002;120(10):1268–79.
8. The Advanced Glaucoma Intervention Study (AGIS): 7. The relationship between control of intraocular pressure and visual field deterioration. The AGIS Investigators. Am J Ophthalmol. 2000;130(4):429–40.
9. Garway-Heath DF, Crabb DP, Bunce C, Lascaratos G, Amalfitano F, Anand N, et al. Latanoprost for open-angle glaucoma (UKGTS): a randomised, multicentre, placebo-controlled trial. Lancet. 2015;385(9975):1295–304.
10. Pazos M, Traverso CE, Viswanathan A. European Glaucoma Society—terminology and guidelines for glaucoma, 6th edition. Br J Ophthalmol. 2025;109(Suppl 1):1–212.
11. European Glaucoma Society. Terminology and guidelines for glaucoma, 5th edition. Br J Ophthalmol. 2021;105(Suppl 1):1–169.
12. Li T, Lindsley K, Rouse B, Hong H, Shi Q, Friedman DS, et al. Comparative effectiveness of first-line medications for primary open-angle glaucoma: a systematic review and network meta-analysis. Ophthalmology. 2016;123(1):129–40.
13. Abegao Pinto L, Sunaric Megevand G, Stalmans I, Azuara-Blanco A, Bron A, Garcia Feijoo J, et al. European Glaucoma Society—a guide on surgical innovation for glaucoma. Br J Ophthalmol. 2023;107(Suppl 1):1–114.
14. Lim R. The surgical management of glaucoma: a review. Clin Experiment Ophthalmol. 2022;50(2):213–31.
15. Sharma A, Tijerina JD, Bitrian E. Minimally invasive, maximally impactful: minimally invasive glaucoma surgery and the changing glaucoma landscape. Curr Opin Ophthalmol. 2024;35(5):409–14.
16. Casson RJ. Medical therapy for glaucoma: a review. Clin Exp Ophthalmol. 2022;50(2):198–212.
17. Robin AL, Muir KW. Medication adherence in patients with ocular hypertension or glaucoma. Expert Rev Ophthalmol. 2019;14(4–5):199–210.
18. Hwang DK, Liu CJ, Pu CY, Chou YJ, Chou P. Persistence of topical glaucoma medication: a nationwide population-based cohort study in Taiwan. JAMA Ophthalmol. 2014;132(12):1446–52.
19. Newman-Casey PA, Robin AL, Blachley T, Farris K, Heisler M, Resnicow K, et al. The most common barriers to glaucoma medication adherence: a cross-sectional survey. Ophthalmology. 2015;122(7):1308–16.
20. Kolko M, Faergemann Hansen R, L GD, Sabelstrom E, Brandel M, Hoiberg Bentsen A, et al. Predictors and long-term patterns of medication adherence to glaucoma treatment in Denmark-an observational registry study of 30 100 Danish patients with glaucoma. BMJ Open Ophthalmol. 2024;9(1). https://doi.org/10.1136/bmjophth-2023-001607.
21. Lacey J, Cate H, Broadway DC. Barriers to adherence with glaucoma medications: a qualitative research study. Eye. 2009;23(4):924–32.
22. Caprioli J, Coleman AL. Intraocular pressure fluctuation a risk factor for visual field progression at low intraocular pressures in the advanced glaucoma intervention study. Ophthalmology. 2008;115(7):1123–9.

23. De Moraes CG, Juthani VJ, Liebmann JM, Teng CC, Tello C, Susanna R Jr, et al. Risk factors for visual field progression in treated glaucoma. Arch Ophthalmol. 2011;129(5):562–8.
24. Sleath B, Blalock S, Covert D, Stone JL, Skinner AC, Muir K, et al. The relationship between glaucoma medication adherence, eye drop technique, and visual field defect severity. Ophthalmology. 2011;118(12):2398–402.
25. Newman-Casey PA, Niziol LM, Gillespie BW, Janz NK, Lichter PR, Musch DC. The association between medication adherence and visual field progression in the Collaborative Initial Glaucoma Treatment Study. Ophthalmology. 2020;127(4):477–83.
26. Buehne KL, Rosdahl JA, Muir KW. Aiding adherence to glaucoma medications: a systematic review. Semin Ophthalmol. 2022;37(3):313–23.
27. Cvenkel B, Kolko M. Devices and treatments to address low adherence in glaucoma patients: a narrative review. J Clin Med. 2022. https://doi.org/10.3390/jcm12010151.
28. Shirley M. Bimatoprost implant: first approval. Drugs Aging. 2020;37(6):457–62.
29. Sirinek PE, Lin MM. Intracameral sustained release bimatoprost implants (Durysta). Semin Ophthalmol. 2022;37(3):385–90.
30. Medeiros FA, Walters TR, Kolko M, Coote M, Bejanian M, Goodkin ML, et al. Phase 3, randomized, 20-month study of bimatoprost implant in open-angle glaucoma and ocular hypertension (ARTEMIS 1). Ophthalmology. 2020;127(12):1627–41.
31. European Medicines Agency. Withdrawal of application for the marketing authorisation of Durysta (bimatoprost intracameral implant) 2024 [cited 2025 6 October]. Available from: https://www.ema.europa.eu/en/documents/medicine-qa/questions-answers-withdrawal-application-marketing-authorisation-durysta-bimatoprost-intracameral-implant_en.pdf.
32. European Medicines Agency. Withdrawal assessment report Durysta. 2024 [cited 2025 6 October]. Available from: https://www.ema.europa.eu/en/medicines/human/EPAR/durysta.
33. Lim KS, Nau CB, O'Byrne MM, Hodge DO, Toris CB, McLaren JW, et al. Mechanism of action of bimatoprost, latanoprost, and travoprost in healthy subjects. A crossover study. Ophthalmology. 2008;115(5):790-5.e4.
34. Bacharach J, Tatham A, Ferguson G, Belalcazar S, Thieme H, Goodkin ML, et al. Phase 3, randomized, 20-month study of the efficacy and safety of bimatoprost implant in patients with open-angle glaucoma and ocular hypertension (ARTEMIS 2). Drugs. 2021;81(17):2017–33.
35. Craven ER, Walters T, Christie WC, Day DG, Lewis RA, Goodkin ML, et al. 24-month phase I/II clinical trial of bimatoprost sustained-release implant (bimatoprost SR) in glaucoma patients. Drugs. 2020;80(2):167–79.
36. Stamer WD, Perkumas KM, Kang MH, Dibas M, Robinson MR, Rhee DJ. Proposed mechanism of long-term intraocular pressure lowering with the bimatoprost implant. Invest Ophthalmol Vis Sci. 2023;64(3):15. https://doi.org/10.1167/iovs.64.3.15.
37. Vagiakis I, Papadopoulou EP, Amaxilati E, Tsiropoulos GN, Konstas AG, Panos GD. Bimatoprost intracameral implant (Durysta(R)): a new era in glaucoma management through sustained-release innovation. Drug Des Devel Ther. 2025;19:703–14.
38. Teymoorian S, Craven ER, Nguyen L, Werts E. Real-world study of the effectiveness and safety of intracameral bimatoprost implant in a clinical setting in the United States. Clin Ophthalmol. 2024;18:187–99.
39. Sarkisian SR Jr, Mitchell EC. Real-world analysis of the efficacy of bimatoprost sustained-release glaucoma implant where American Indians Comprise the Largest Minority Population. Clin Ophthalmol. 2024;18:917–27.
40. Ali AA, Aviles Elescano D, Grover DS. Bimatoprost SR for glaucoma therapy implanted at the slit-lamp in a real-world setting. Clin Ophthalmol. 2024;18:1371–7.
41. Kolko M, Tatham AJ, Lim KS, Wells AP, Shiu M, Uy HS, et al. Phase 3, randomized, comparison study of intracameral bimatoprost implant 10 microg and selective laser trabeculoplasty. Am J Ophthalmol. 2025;272:19–37.
42. Stewart J. IDose TR FDA approval history. 2024 [cited 2025 10 October]. Available from: https://www.drugs.com/history/idose-tr.html.
43. Berdahl JP, Sarkisian SR Jr, Ang RE, Doan LV, Kothe AC, Usner DW, et al. Efficacy and safety of the travoprost intraocular implant in reducing topical IOP-lowering medication burden in patients with open-angle glaucoma or ocular hypertension. Drugs. 2024;84(1):83–97.
44. Teymoorian S, Kaur J. Travoprost intracameral implant in eyes with glaucoma or ocular hypertension: early short-term real-world outcomes. Clin Ophthalmol. 2025;19:157–66.
45. Denis P, Covert D, Realini A. Travoprost in the management of open-angle glaucoma and ocular hypertension. Clin Ophthalmol. 2007;1(1):11–24.
46. Sarkisian SR, Ang RE, Lee AM, Berdahl JP, Heersink SB, Burden JH, et al. Travoprost intracameral implant for open-angle glaucoma or ocular hypertension: 12-month results of a randomized, double-masked trial. Ophthalmol Ther. 2024;13(4):995–1014.
47. Singh IP, Berdahl JP, Sarkisian SR Jr, Voskanyan LA, Ang RE, Doan LV, et al. Long-term safety and efficacy evaluation of travoprost intracameral implant based on pooled analyses from two phase III trials. Drugs. 2024;84(10):1299–311.
48. Sarkisian SR Jr, Ang RE, Lee AM, Berdahl JP, Heersink SB, Burden JH, et al. Phase 3 randomized clinical trial of the safety and efficacy of travoprost intraocular implant in patients with open-angle glaucoma or ocular hypertension. Ophthalmology. 2024;131(9):1021–32.
49. Bacharach J, Doan LV, Stephens KG, Usner DW, Kothe AC, Katz LJ, et al. Travoprost intracameral implant demonstrates superior IOP lowering versus topical prostaglandin analog monotherapy in patients with open-angle glaucoma or ocular hypertension. Ophthalmol Ther. 2024;13(9):2357–67.
50. Singh IP, Voskanyan LA, Barber KM, Burden JH, Connolly L, Katz LJ, et al. Safety and efficacy of travoprost intracameral implant administered in combination with cataract surgery. Ther Adv Ophthalmol. 2025. https://doi.org/10.1177/25158414241310275.
51. Envisia therapeutics. envisia therapeutics announces positive three-month interim results of low dose ENV515 in patients with glaucoma. 2016 [cited 2025 16 July]. Available from: https://www.prnewswire.com/news-releases/envisia-therapeutics-announces-positive-three-month-interim-results-of-low-dose-env515-in-patients-with-glaucoma-300261688.html.
52. Ocular Therapeutix. Ocular Therapeutix™ announces positive phase 2 PAXTRAVA™ glaucoma data at the American Society of Cataract and Refractive Surgery 2024 annual meeting. 2024 [cited 2025 16 July]. Available from: https://www.globenewswire.com/news-release/2024/04/06/2858799/0/en/Ocular-Therapeutix-Announces-Positive-Phase-2-PAXTRAVA-Glaucoma-Data-at-the-American-Society-of-Cataract-and-Refractive-Surgery-2024-Annual-Meeting.html.
53. Kompella UB, Hartman RR, Patil MA. Extraocular, periocular, and intraocular routes for sustained drug delivery for glaucoma. Prog Retin Eye Res. 2021;82:100901. https://doi.org/10.1016/j.preteyeres.2020.100901.
54. Goldberg DF, Williams R. A phase 2 study evaluating safety and efficacy of the latanoprost punctal plug delivery system (L-PPDS) in subjects with ocular hypertension (OH) or open-angle glaucoma (OAG). Invest Ophthalmol Vis Sci. 2012;53(14):5095.
55. Perera SA, Ting DS, Nongpiur ME, Chew PT, Aquino MC, Sng CC, et al. Feasibility study of sustained-release travoprost

punctum plug for intraocular pressure reduction in an Asian population. Clin Ophthalmol. 2016;10:757–64.
56. Kesav NP, Young CEC, Ertel MK, Seibold LK, Kahook MY. Sustained-release drug delivery systems for the treatment of glaucoma. Int J Ophthalmol. 2021;14(1):148–59.
57. Lee P, Shen Y, Eberle M. The long-acting ocusert-pilocarpine system in the management of glaucoma. Invest Ophthalmol. 1975;14(1):43–6.
58. Brandt JD, Sall K, DuBiner H, Benza R, Alster Y, Walker G, et al. Six-month intraocular pressure reduction with a topical bimatoprost ocular insert: results of a phase II randomized controlled study. Ophthalmology. 2016;123(8):1685–94.
59. Brandt JD, DuBiner HB, Benza R, Sall KN, Walker GA, Semba CP, et al. Long-term safety and efficacy of a sustained-release bimatoprost ocular ring. Ophthalmology. 2017;124(10):1565–6.
60. Creech JL, Chauhan A, Radke CJ. Dispersive mixing in the posterior tear film under a soft contact lens. Ind Eng Chem Res. 2001;40(14):3015–26.
61. Fea AM, Vallino V, Cossu M, Marica V, Novarese C, Reibaldi M, et al. Drug delivery systems for glaucoma: a narrative review. Pharmaceuticals (Basel). 2024. https://doi.org/10.3390/ph17091163.
62. Kompella UB, Kadam RS, Lee VH. Recent advances in ophthalmic drug delivery. Ther Deliv. 2010;1(3):435–56.
63. Franco P, De Marco I. Contact lenses as ophthalmic drug delivery systems: a review. Polymers (Basel). 2021. https://doi.org/10.3390/polym13071102.
64. American Academy of Ophthalmology. Subconjunctival latanoprost implant shows sustained IOP reduction through 3 months. Glaucoma Education Center 2017 [cited 2025 16 July]. Available from: https://www.aao.org/education/headline/subconjunctival-latanaprost-implant-shows-sustaine.
65. Wong TT, Novack GD, Natarajan JV, Ho CL, Htoon HM, Venkatraman SS. Nanomedicine for glaucoma: sustained release latanoprost offers a new therapeutic option with substantial benefits over eyedrops. Drug Deliv Transl Res. 2014;4(4):303–9.
66. Elhusseiny AM, Aref AA. Sustained release therapies with the prostaglandin analogues intracameral implants. Ophthalmol Ther. 2024;13(7):1833–9.
67. Jarem L. A drug-eluting IOL may help expand glaucoma treatment options. 2025 [cited 2025 20 July]. Available from: https://www.aao.org/education/headline/drug-eluting-iol-may-help-expand-glaucoma-treatmen.
68. Stagg BC, Granger A, Guetterman TC, Hess R, Lee PP. The burden of caring for and treating glaucoma: the patient perspective. Ophthalmol Glaucoma. 2022;5(1):32–9.
69. Safitri A, Konstantakopoulou E, Hu K, Gazzard G. Treatment expectations in glaucoma: what matters most to patients? Eye. 2023;37(16):3446–54.
70. Weber C, Quintin P, Holz FG, Fea A, Mercieca K. Ocular drug delivery systems: glaucoma patient perceptions from a German university hospital eye clinic. Graefes Arch Clin Exp Ophthalmol. 2024;262(2):545–56.
71. Lewis RA, Christie WC, Day DG, Craven ER, Walters T, Bejanian M, et al. Bimatoprost sustained-release implants for glaucoma therapy: 6-month results from a phase I/II clinical trial. Am J Ophthalmol. 2017;175:137–47.
72. Szekely G, Katz LJ, Voskanyan LA, Chu I, Seal J, Yang J-Y, et al. Travoprost intraocular implant (iDose® TR) delivers therapeutically relevant and durable aqueous humor drug concentrations at 24 months and demonstrates safety of repeat implant administration. Invest Ophthalmol Vis Sci. 2024;65(7):1913.
73. Weinreb RN, Bacharach J, Brubaker JW, Medeiros FA, Bejanian M, Bernstein P, et al. Bimatoprost implant biodegradation in the phase 3, randomized, 20-month ARTEMIS studies. J Ocul Pharmacol Ther. 2023;39(1):55–62.
74. Nystuen A, Gonzalez-Lopez E, Kauper KA, Eade K, Aaberg TM Jr. Neuroprotective properties of ciliary neurotrophic factor in the retina for the treatment of macular telangiectasia type 2. Cytokine Growth Factor Rev. 2025;84:12–9. https://doi.org/10.1016/j.cytogfr.2025.06.005.
75. Tao W, Wen R, Goddard MB, Sherman SD, O'Rourke PJ, Stabila PF, et al. Encapsulated cell-based delivery of CNTF reduces photoreceptor degeneration in animal models of retinitis pigmentosa. Invest Ophthalmol Vis Sci. 2002;43(10):3292–8.
76. Chew EY, Clemons TE, Jaffe GJ, Johnson CA, Farsiu S, Lad EM, et al. Effect of ciliary neurotrophic factor on retinal neurodegeneration in patients with macular telangiectasia type 2: a randomized clinical trial. Ophthalmology. 2019;126(4):540–9.
77. Tao W, Wen R, Goddard MB, Sherman SD, O'Rourke PJ, Stabila PF, et al. Encapsulated cell-based delivery of CNTF reduces photoreceptor degeneration in animal models of retinitis pigmentosa. Invest Ophthalmol Vis Sci. 2002;43(10):3292–8.
78. FDA. Center for Biologics Evaluation and Research (CBER) product approval information: ENCELTO. 2025 [cited 2025 18 July]. Available from: https://www.fda.gov/vaccines-blood-biologics/center-biologics-evaluation-and-research-cber-product-approval-information/encelto.
79. Goldberg JL, Beykin G, Satterfield KR, Nunez M, Lam BL, Albini TA. Phase I NT-501 ciliary neurotrophic factor implant trial for primary open-angle glaucoma: safety, neuroprotection, and neuroenhancement. Ophthalmol Sci. 2023;3(3):100298. https://doi.org/10.1016/j.xops.2023.100298.