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QLAUKOMANIN MÜALİCƏSİNDƏ MİKROİNVAZİV CƏRRAHİYYƏ: DÜNƏNİ, BU GÜNÜ VƏ SABAHI (ƏDƏBİYYAT İCMALI)

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XÜLASƏ

Dünyada qlaukomanın yüksək yayılması və xəstələrin sayının daha da artması bu patologiyanın müalicəsi üçün innovativ metodların axtarılması zərurətini ortaya qoyur.

Hal-hazırda qlaukoma müalicəsi müxtəlif dərman qrupları və lazer üsullarını əhatə edir. Dərman və lazer müalicəsinin qeyri-kafi effektivliyi və ya məhdudiyyətləri alternativ cərrahi yanaşmanın seçilməsi üçün əsasdır. Lakin, gözdaxili təzyiqin (GDT) optimal kompensasiyasına nail olmaqla yanaşı, müasir qlaukoma cərrahiyyəsindəki tendesiyalar əməliyyatların keçirilmə müddətini azaltmağa, toxuma zədələrini minimuma endirməyə, sabit və uzunmüddətli hipotenziv təsirin təmin edilməsinə yönəlmişdir. Son onilliklərdə müxtəlif mikroinvaziv qlaukoma cərrahiyyəsi (MİQC) üsulları ortaya çıxmışdır.

Bu icmalda PubMed, e-library, Scopus, Google Scholar bazalarından istifadə edərək MİQC mövzusunda mövcud nəşrlər təhlil edilmişdir. Məlumat sistemləşdirilmiş və hazırda mövcud olan MİQC texnikalarının ən əhatəli təsnifatının yaradılması üçün əsas rol oynamışdır. Bu təsnifat onların texniki xüsusiyyətlərini və göz drenaj sisteminin müxtəlif strukturlarına təsir mexanizmlərini nəzərə alaraq hazırlanmışdır. MİQC-nin effektivliyini, yüksək təhlükəsizlik profilini, uzunmüddətli nəticələrin sabitliyini və sürətli reabilitasiyasını sübut edən çoxmərkəzli tədqiqatların və meta-analizlərin nəticələri təqdim olunur. Bu, xəstəliyin erkən və inkişaf etmiş mərhələlərində MİQC-nin şübhəsiz tələbatını və potensialını göstərir.

Şübhəsiz ki, effektivlik və mümkün risklər arasında mütləq balansını nəzərə alarkən, MİQC sahəsində əlavə tədqiqatların praktikada istifadəsi üçün göstərişləri genişləndirmək məqsədilə aktualdır.

Açar sözlər: *qlaukoma, gözdaxili maye axını, mikroinvaziv qlaukoma cərrahiyyəsi, qoniotomiya, trabekulotomiya, kanaloplastika, viskodilatasiya*

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MICROINVASIVE SURGERY IN GLAUCOMA TREATMENT: PAST, PRESENT AND FUTURE (LITERATURE REVIEW)

https://

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SUMMARY

The high prevalence of glaucoma worldwide and the expected further increase in the number of patients necessitate the search for innovative treatment methods.
Currently, ophthalmology has a wide arsenal of tools for the treatment of glaucoma, including various groups of medications and laser techniques. Cases of insufficient effectiveness or limitations of medical and laser treatment serve as the basis for choosing surgical methods. However, alongside achieving targeted level of intraocular pressure (IOP), modern trends in glaucoma surgery are also directed towards minimizing tissue trauma during surgeries, reducing procedure time, and ensuring a stable and long-lasting hypotensive effect. Over the past decades, numerous techniques of minimally invasive glaucoma surgery (MIGS) have been emerged.
This review was conducted by analysis of current publications dedicated to MIGS, using the PubMed, e-library, Scopus, and Google Scholar databases. The information was systematized and served as the basis for creating the most comprehensive classification of existing MIGS techniques to date, taking into account their technical features, principles, and action mechanisms and impact on various structures of the eye's drainage system. Data from multicenter studies and meta-analyses are presented, demonstrating the effectiveness, high safety profile, stability of long-term results, and rapid patient rehabilitation with the use of minimally invasive glaucoma surgery. This indicates the undeniable demand and promising nature of MIGS at the mild and moderate glaucoma.
Nevertheless, there is no doubt about the relevance of further research of MIGS field in order to expand its practical indications, with the balance between effectiveness and possible risks.

Key words: *glaucoma, aqueous humor outflow, microinvasive glaucoma surgery, MIGS, goniotomy, trabeculotomy, canaloplasty, viscodilation*

Purpose – to highlight the history of Microinvasive Glaucoma Surgery (MIGS), to analyze the current pattern and probable development paths of this most promising and pathogenetically oriented direction in glaucoma treatment.

Material and methods

The PubMed, e-library, Scopus and Google Scholar databases were comprehensively searched using primary and secondary keywords “glaucoma”, “aqueous humor outflow”, “microinvasive glaucoma surgery”, “MIGS”, “goniotomy”, “trabeculotomy”, “canaloplasty”, “viscodilation” without language and time restriction. A total of 173 publications were pre-screened for relevance to the topic, resulting in 144 articles being selected for the full text assessment. The remaining 95 eligible publications were included in the final review and cited. The timeframe is 2006-2025 years. They consisted of 49 randomized controlled trials (RCTs), 21 retrospective meta- and bibliometric analyses and systematic reviews, and a number of additional observational and experimental studies, as well as national protocols and guidelines, which provide a comprehensive overview of the MIGS current situation, theoretical justifications and clinical implementations.

Introduction

A total of 80 million people globally is currently affected by glaucoma. In accordance with the meta-analysis done by Blindness and Vision Impairment Collaborators et al. (244 authors), glaucoma is the 2nd leading cause of blindness in those aged 50 years and older in 2020 with 3.61 million affected people (2.81-4.42). Primary open-angle glaucoma (POAG) is a most frequent cause of irreversible blindness in the world for the last 20 years: such the conclusions were made after meta-analysis of 50 researches with a total of 198,259 patients. Africa and Asia have the highest prevalence of POAG (4%) among all continents. Another meta-analysis, which included a total of 26,993 patients, stated that the prevalence of glaucoma (POAG) in Europe is expected to grow significantly due to progressive aging of population [1-6].

This situation increases interest in studying the problem. Semi-automated bibliometric analysis holds on all primary peer-reviewed researches on eye health published between 2000 and 2019 analysed 156,954 articles. 11.0% were on glaucoma being the most frequent through the leading causes of vision impairment. The quantity and quality of articles dedicated to glaucoma and published in peer-reviewed biomedical journals indexed in different databases are constantly increasing. In accordance with the Dr R. Li’s bibliometric review, during the period between 1992 and 2023 years there were 1533 MIGS-related publications published in 139 journals and authored by 4482 authors across 57 countries [7, 8].

Recently Microinvasive or Minimally Glaucoma Surgery (MIGS) has become widespread in the world. In 2017 MIGS accounted for 131,935 cases (75.5%) of all glaucoma surgeries in USA, instead of 22,862 (13.1%) for trabeculectomy and 19,991 (11.4%) for Glaucoma Drainage Device (GDD). The annual growth rate for these procedures in Germany was very high in the first years (858% in 2013, 218% in 2015 yy.) and settled at around 16-35% later (35% in 2017, 29% in 2018 yy.). MIGS combined with phacoemulsification was the most preferred procedure for non-operated mild to moderate POAG – 94.6%, and normotensive glaucoma (NTG) – 67.3% associated with cataract in Japan in 2024. During 2010-2020 yy. in Azerbaijan non-penetrating/MIGS, GDD implantations or combined cataract-glaucoma surgeries were performed in 30.2% of glaucoma cases, while the burden of glaucoma in our country averages 14.2+1.3% of all eye and adnexa diseases, recorded between 2010 and 2019, with a prevalence rate of 14.5+18.7% [9 – 14].

The “2025 Glaucoma Surgical Device Market Report” provides a data-driven analysis of the global market for glaucoma surgical devices, offering comprehensive coverage of current technologies, innovation pipelines, competitive positioning and growth opportunities. According to this report microstents took 44.8% of glaucoma surgical devices market, tube shunts – 10.9%, subconjunctival shunts – 8.4%, canal surgery devices – 23.5%, lasers – 12.3%. Market demands show us the current pattern, highlight the forecast based on the strategic positioning and outlook in this, so rapidly developing field [15].

Glaucoma surgery field is witnessing several trends shaping its growth trajectory. The main one is increasing numbers of MIGS as an effective and early interventional alternative to traditional filtering surgeries, alongside with more safety and enhanced patient comfort. The growing preference for MIGS is further driven by demand for innovative surgical solutions and relatively earlier-stage diagnosis compared with previous decades.

It's very important to state, that MIGS is not a direct continuation of GDD, but two distinct surgical philosophies in glaucoma management with just the same main goal – to lower the IOP and, accordingly, to reduce the impact of glaucoma on visual functions (**Table 1**).

Definition of term "MIGS" varied across the world. Thus, Food and Drug Administration (FDA) of the USA defines MIGS as "devices which enhance outflow with minimal conjunctival or sclera dissection". The European Glaucoma Society Guidelines excludes bleb-forming procedures and/or device requiring conjunctival dissection for implantation [16, 17].

"MIGS is the newest, less invasive and more successive glaucoma treatment approach meaningly called a "paradigm shift" – Dhawale K.K. [18]. "The development of MIGS was intended to provide safe and modestly efficacious modalities for early intervention of mild-to-moderate glaucoma, with minimal trauma and rapid recovery" – Chan P.P.M. [19].

The term MIGS – Micro Invasive Glaucoma Surgery - was first coined in 2008 by Dr Iqbal Ike K Ahmed, MD, FRCSC, a Canadian ophthalmologist internationally recognized for his work in glaucoma surgery and innovation.

Generally, GDDs are implant-based shunt systems diverting aqueous humor to an

Table 1. *Differences between GDD and MIGS*

	GDD	*MIGS*
Indications	Moderate to advance, refractory, uncontrolled, failed trabeculectomy and medication	Mild to moderate glaucoma
Outflow mechanism	Diverts aqueous humor from anterior chamber through tube over the plate	Enhances natural aqueous outflow pathways
Invasiveness	More invasive, longer surgery, requires conjunctival manipulation	Minimally invasive, shorter surgery time
Surgical approach	Ab externo, conjunctival/sclera dissection, plate fixation	Ab interno, micro-incisional, minimal tissue disruption
IOP reduction	Significant	Moderate
Medication reduction	Reduces or eliminates need for medications	Decreases burden, but still need the medications
Safety profile	Higher risk: hypotony, diplopia, tube erosion, endothelial cell loss, fibrosis	High safety, low risk of serious complications, fast recover
Durability	Long-term effectiveness	May need repeat or combined procedures; limited long-term data for some devices/ procedures
Role in treatment algorithm	Last solution for refractory cases when other options failed	Earlier intervention, bridge between meds and more invasive surgery

external plate and creating a subconjunctival reservoir – bleb. They are usually implemented for moderate to advanced OAG with history of failed surgeries, uncontrolled and refractory glaucoma [20, 21]. We covered this theme in details in our previous article [22].

MIGS are micro-scale, less invasive procedures enhancing the natural outflow – via trabecular meshwork (TM) or the suprachoroidal pathway. MIGS are usually implemented for earlier stages of glaucoma process, in mild to moderate glaucoma. The need for less invasive surgical options in the initial stages of glaucoma has led to an extensive investigation into surgical methods designed to enhance patient quality of life by effectively controlling IOP and minimizing intra- and postoperative complications [23, 24].

The actual algorithms are as demonstrated in Table 1:

- GDD: later, more aggressive, draining through artificial bypass;
- MIGS: earlier, safer, draining through physiological pathways.

The conventional aqueous humor pathway covers approximately 83-96% of the total outflow and can be divided to proximal and distal. Proximal segment starts in the anterior chamber and extends from the trabecular meshwork through Schlemm's canal (SC) and collector channels, where the distal segment begins and then progresses to the deep scleral venous venosus plexus. Here it connects with the aqueous veins, then flows into the episcleral veins. The main resistance to AH (aqueous humor) outflow concentrated in the inner wall of Schlemm's canal, which includes the juxtacanalicular tissue and endothelium [25, 26].

Having reviewed an extensive volume of the scientific literature dedicated to MIGS, we can assert that, to date, no adequate, logical and pathogenetically oriented classification of this treatment modality exists. Taking into account the growing relevance of this treatment modality, we deem it necessary to develop a contemporary classification that would most comprehensively reflect current trends, structure the indications for its application and clarify the vector of expectations.

From our point of view, the MIGS should be classified to 2 main groups: "with device" and "device-free".

In current research we focus on MIGS without devices and structure the classification of this surgical treatment modality in accordance with the action mechanisms (**Table 2)**.

Table 2. *Classification of device-free MIGS*

Type	Name of procedure/ tecnique	Inventor	Manufacturer	Mechanism	Key features	Indications	Severity of glaucoma	IOP reduction
TM Targeting Procedures	Trabectome®	Dr. George Baerveldt, University of California, USA	MicroSurgical Technology, Inc., USA	Electrocautery TM ablation	Ablates TM tissue segmentally (30-180°), bleeding control	OAG, PXG, PG, SIG	Early to moderate	20-40%
	KDB (Kahook Dual Blade)	Dr. Malik Y. Kahook, University of Colorado, USA	New World Medical, Inc., USA	Dual blade TM excision/ goniotomy	Removes a strip of TM segmentally (90-180°), low cost	OAG,RG, PXG, PG	Mild to moderate	20-40%
	Tanito Microhook	Dr. Masayuki Tanito, Shimane University Hospital, Japan	Inami & Co., Ltd., Japan	Dissection of the TM and the inner wall of Schlemm's canal	240° cutting arc	OAG,RG, PXG, PG	Mild to moderate	20-30%
	TrabEx®/TrabEx PRO®	In-house development	MicroSurgical technology, Inc., USA	Serrated blade excisional goniotomy	Segmental, built-in irrigation and aspiration	OAG	Mild to moderate	20-35%
	TRAB360 (Trabeculotomy ab interno)	In-house development.	Sight Sciences, Inc., USA	360° circumferential trabeculotomy	Circumferential TM opening using a looped device	OAG,PXG, juvenile or congenital glaucoma	Mild to moderate	20-40%
	SION Surgical Instrument	Dr. Felipe A. Medeiros, Duke Eye Center, USA	Sight Sciences, Inc., USA	Mechanical TM stripping	Micro-engineered tip peels segmental, wider continuous TM strip, no blade trauma	OAG	Mild to moderate	20-35%
	GATT (Gonioscopy-assisted transluminal trabeculotomy)	Dr. Davinder S. Grover	-	Transluminal 360° trabeculotomy	Circumferential 360° TM opening using a suture or microcatheter	OAG,PXG, juvenile or congenital glaucoma	Mild to advanced	30-50%
	iAccess® Precision Blade	Mark J. Gallardo, MD, El Paso Eye Surgeons, P.A., USA	Glaukos Corporation, USA	Microgoniotomy	Controlled TM microincisions, flexible targeting	OAG	Mild to moderate	15-30%
	BANG (Bent Ab Interno Needle Goniotomy)	Dr. Arsham Sheybani,MD, WashU Medicine, USA	-	Goniotomy/ goniectomy	Usage of the standard hypodermic needle as a makeshift goniotome for 180° TM excising	OAG	Mild to moderate	25-35%

Type	*Name of procedure/ tecnique*	*Inventor*	*Manufacturer*	*Mechanism*	*Key features*	*Indications*	*Severity of glaucoma*	*IOP reduction*
TM Targeting Procedures	Gonio Scratch (GS-Phaco)	Dr. Kana Tokumo, PhD., Hiroshima University	Diamond Dusted Sweeper, manufactured by DORC	Gonio scratching	Usage of existing tool – Diamond Dusted Sweeper-originally designed for removing retinal membranes	OAG	Mild tp moderate	15-30%
	ELT (Excimer Laser Trabeculostomy) by LIOS® system	Dr. Michael S. Berlin, MD, Jules Stein Eye Institute, UCLA, USA	EliosVision, Inc., USA, now Bausch&Lomb, (LIOS® system)	Laser TM fenestration	Precise perforations using 308 nm excimer laser, minimal tissue disruption	OAG	Mild	15-25%
Hybrid	STREAMLINE® Surgical System	In-house development	New World Medical Inc., USA	TM perforation + viscodilation	Microgoniotomy and canal + collector channels dilation	Ocular hypertension, OAG	Mild to moderate	20-35%
	OMNI	In-house development	Sight Sciences, Inc., USA	360° viscodilation	Canaloplasty + viscodilation + trabeculotomy (cleaving/ incising TM)	POAG, PXG, PG, SIG juvenile or congenital glaucoma	Mild to moderate	15-30%
Schlemm's Canal and Collector Channel-Based MIGS	ABiC (Ab-interno canaloplasty)	Dr. Robert Stegmann, South Africa, Dr. Ike K. Ahmed, Canada	-	Viscodilation only	Expands Schlemm's canal without cutting TM	POAG, PXG, PG, SIG	Mild	15-30%
	iTrack/iTrack advance	Dr. Murat Ünal with iScience Engineering team	Nova Eye Medical Inc., USA	Full 360° viscodilation of Schlemm's canal	Delivers viscoelastic into Schlemm's canal/mechanical breaking of adhesions	POAG, OAG, PXG, PG	Mild to moderate	25-40%
	Visco® 360 Viscosurgical System	In-house development	Sight Sciences, Inc., USA	Full 360° viscodilation of Schlemm's canal	Delivers viscoelastic into Schlemm's canal	POAG,PXG, PG	Mild	15-30%
	Via 360® Surgical System	In-house development	New World Medical Inc., USA	Up to 360° viscodilation of Schlemm's canal	On-demand/multi-axial delivery of viscoelastic	POAG, OAG, PXG, PG	Mild to moderate	25-40%
	iPrime Viscodelivery System	In-house development	Glaukos Corporation, USA	Viscodilation	More consistent dosing of viscoelastic	POAG, OAG, PXG, PG	Mild to moderate	20-35%
Cyclodestructive procedures	ECP (Endoscopic Cyclophotocoagulation) by Leos®Laser Endoscopy System	Dr. Martin Uram, MD	BVI Medical, Inc., USA	Laser ablation of ciliary processes	Targets aqueous inflow by ablating of ciliary processes	POAG, OAG, PXG, PG	Mild-to-moderate	20-40%

The first big group of device-free MIGS includes the ***Trabecular Meshwork targeting*** procedures. These surgeries remove, excise or ablate a portion of pathologically changed TM to create or to re-establish a direct pathway for aqueous humor to flow into Schlemm's canal and collector channels. In this case, the IOP reduction occurs more physiologically, without any device implantation or big volume of tissue removal. This ab interno MIGS types are the most popular due to high safety profile, ability to be combined with the cataract surgery and fast recovery.

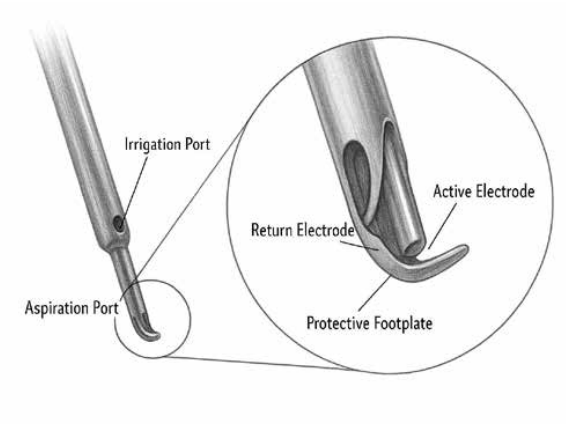

Figure 1. *Trabectome®*

Trabectome® (MicroSurgical Technology, formerly NeoMedix Corporation, USA) (**Fig. 1**) was invented by Dr George Baerveldt, MD, and Dr Roy S. Chuck, MD, PhD, and received the FDA approval in 2004. It is the one of the earliest and most established MIGS. The performing device consists of a handle equipped with an irrigation/aspiration system and a bipolar high-frequency electrocautery (plasma ablation at ≈ 550 kHz). A three-stage foot pedal sequentially initiates the processes of ablation, irrigation and aspiration. The system operates by removing a portion (strip) of the trabecular meshwork and the inner wall of Schlemm's canal (typically over 60-180°), thereby facilitating the outflow of aqueous humor from the anterior chamber directly into the Schlemm's canal and collector channels. This technology minimizes tissue trauma, reduces the inflammatory response and scarring in the postoperative period. Reduces IOP in the range of 22 to 42%. Effective for various subtypes and stages of glaucoma, as well as for refractory glaucoma, unsuccessful trabeculectomy and shunt surgery [19, 27, 28, 29].

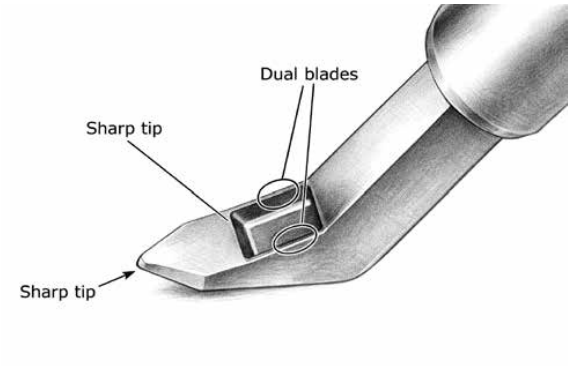

Figure 2. *Kahook Dual Blade*

Kahook Dual Blade (KDB/KDB GLIDE), (New World Medical, Inc., USA) (**Fig. 2**) – is a sectoral (90°) ab-interno MIGS technique affecting the TM and internal wall of SC. The device for performing the excisional goniotomy by removing a strip of trabecular meshwork was invented by Dr Malik Y. Kahook (Sue Anschutz-Rodgers Eye Center, University of Colorado) in 2015. The single-use instrument with 2 parallel blades fixed on the opposite sides of 230 µm width plate. The pointed ramp lifts and stretches the TM, then blades excise it and tissue removes by aspiration. Second-generation – KDB Glide – is the device with beveled edges and rounded footplate's corners to facilitate easier passage within the canal. Can be performed standalone or combined with the cataract surgery. It's very popular due to simplicity, excellent tissue removal and strong, long-term IOP reduction. KDB has become one of the world's most commonly used tools in a minimally invasive approach for glaucoma treatment [30–33]. It was noted by The Ophthalmologist Magazine in its 2015 Innovation Awards for increasing patient safety and low cost (https://

theophthalmologist.com/issues/2015/articles/dec/the-2015-innovation-awards-are-here).

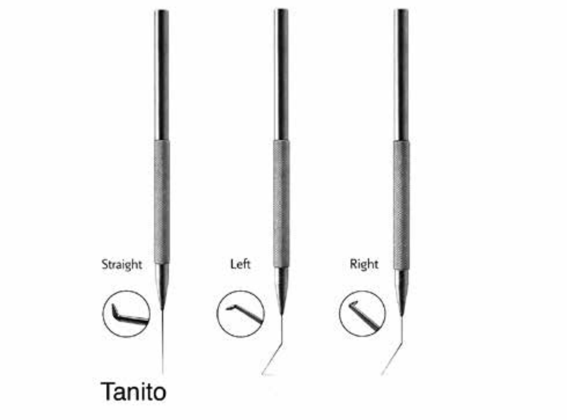

Figure 3. *Tanito Microhook*

Tanito Microhook (Inami & Co., Ltd.) (**Fig. 3**) – is a specialized metallic instrument designed for ab-interno trabeculotomy. It was developed by Dr. Masayuki Tanito, MD, PhD, Shimane University Hospital, Japan. The improved design features three hook types: straight, right-curved, and left-curved. The straight hook is suitable for temporal and superior approaches, whereas the curved hooks are intended for nasal approach. This configuration allows controlled dissection of the trabecular meshwork and the inner wall of Schlemm's canal under gonioscopic visualization, with circumferential advancing of the hook tip. The total achievable cutting arc is 240° [34, 35, 36].

Figure 4. *TrabEx PRO®*

TrabEx®/TrabEx PRO® (MisroSurgical Technology, USA) (**Fig. 4**) - is a single-used device with serrated trapezoidal dual blades designed for excision of the trabecular meshwork through a micro corneal incision. The tip of the improved version of device TrabEx PRO® features integrated ports for irrigation and aspiration. Irrigation creates pressure in the anterior chamber, helping prevent intraoperative backflow of blood into the anterior chamber angle and ensuring maximum visibility during surgery. Aspiration draws the TM toward the blades, promoting precise and complete tissue excision [37, 38, 39].

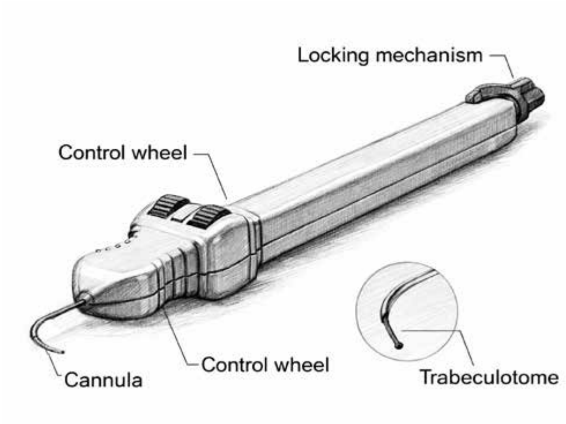

Figure 5. *TRAB® 360*

TRAB® 360 (Sight Sciences, Inc., USA) (**Fig. 5**) is the forerunner of OMNI. It cannulates Schlemm's canal without viscodilation and performs a full 360° trabeculotomy via an ab interno approach. A blunt polymer trabeculotome is advanced through the tip of a curved cannula and mechanically cleave TM when it is withdrawn from the eye. It can be used alone or in conjunction with cataract surgery [40, 41].

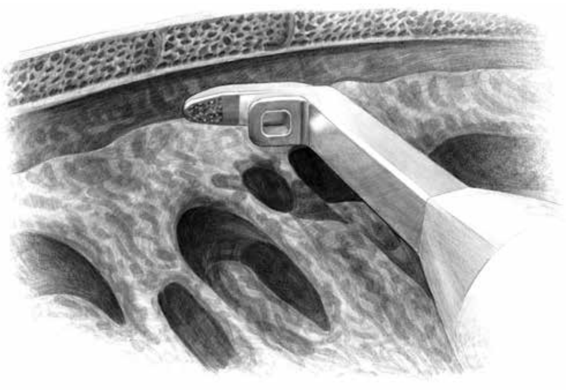

Figure 6. *SION Surgical Instrument*

The **SION Surgical Instrument**, (Sight Sciences, Inc., USA) (**Fig. 6**), is a sterile, disposable, hand-operated device designed for goniotomy. A bladeless design with a rounded tip, manufactured using specialized lasers, allows for puncture and gentle excision of the trabecular meshwork. A built-in tissue collection window captures and removes excised tissue [42, 43].

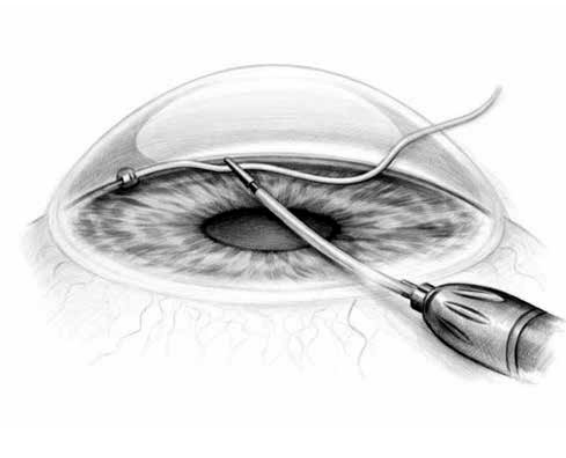

Figure 7. *GATT (Gonioscopy-Assisted Transluminal Trabeculotomy*

GATT – Gonioscopy-Assisted Transluminal Trabeculotomy (Fig. 7) – is a minimally invasive surgical treatment for open-angle glaucoma. First described by Davinder S. Grover et al. in 2014, it is a modification of trabeculotomy with an ab interno corneal approach instead of the traditional ab externo approach through the conjunctiva and sclera, which reduces the risk of scar tissue formation and ensures a lasting hypotensive effect in the late postoperative period. This procedure involves a 360° dissection of the TM and the inner wall of the Schlemm's canal. Trabeculotomy is performed using a microcatheter or prolene suture under direct gonioscopic guidance. It's important to state, that GATT is the special surgical technique, not a special device, and can use microcatheter or suture for this purpose [44–49].

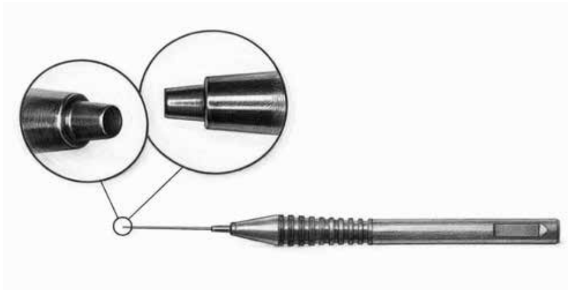

Figure 8. *iAccess Precision Blade*

iAccess® Precision Blade (Glaukos Corporation, USA) (**Fig. 8**) is a tiny, circular 30-gauge precision blade made from nitride-coated titanium. By incising and excising the trabecular meshwork and inner wall of the Schlemm's canal, this instrument creates the possibility to make goniotomy procedures more precise and patient-oriented. It can open the TM over an area greater than 90°. iAccess can preserve significantly more tissue compared to other procedures in use, helping to maintain the blood-aqueous barrier and the pulsatile pumping mechanism of TM/SC complex that facilitates outflow [50, 51].

Bent Ab Interno Needle Goniotomy (BANG) – performed using a 25G needle with a curved tip, is designed to remove a strip of TM, providing direct access of aqueous humor to the Schlemm's canal. The tangled needle configuration improves the surgeon's ability to access and navigate the anterior chamber angle with greater control, especially in anatomically complex areas. It facilitates precise penetration of the trabecular meshwork, ensures smoother entry into SC, and minimizes damage to collateral tissues. The ab interno procedure preserves conjunctiva, limits postoperative inflammation and promotes faster recovery. Its simple design improves surgical ergonomics [52–55].

GS-Phaco (Gonio Scratch) – a novel angle-based MIGS for the patients with OAG and cataract. It performs by Diamond Dusted Sweeper developed by Yasuo Tano et al. in 1997 as the vitreoretinal surgical tool, and manufactured by Dutch Ophthalmic Research Center (DORC) for gentle removing of deposits/obstructions from trabecular meshwork and enhancing natural drainage pathway. According to some publications, it demonstrates the sustained and significant IOP-lowering, up to 80.9% surgical success rate and promising safety profile [56, 57].

ELT (Excimer Laser Trabeculostomy) was intended by Dr. Michael S. Berlin, MD, at the Jules Stein Eye Institute, UCLA, USA, in 1987. It is an endoscopically guided xenon chloride excimer laser with a wavelength of 308 nm (non-termal). The laser beam is delivered to the target area via fiber optics through a limbal paracentesis, preserving the conjunctiva. Excimer laser photocoagulation allows the ablation of the juxtacanalicular wall of the TM and the internal wall of Schlemm's canal to restore the physiological outflow of aqueous humor through the physiological drainage pathways without the formation of an external filtration pad. It causes virtually no thermal damage, minimizing the inflammatory response, and does not provoke reparative or scarring process. ELT can be performed alone, in combination with cataract surgery and after previously undergone filtering surgery. CE-marked in Europe since 2014 [58, 59, 60].

Several MIGS procedures are being classified as hybrid, meaning they combine Trabecular Meshwork Targeting with the viscodilation or canaloplasty of Schlemm's canal using ophthalmic viscosurgical device (OVD) to dilate the canal, stretch the TM and approach distal collector channels. This dual solution addresses multiple points of resistance in conventional outflow pathway to enhance the efficacy in implant-free and ab interno conditions.

Figure 9. *Streamline Surgical System*

The **Streamline Surgical System** (New World Medical, Inc., USA) (**Fig. 9**) received FDA approval in 2021 for the treatment of patients with ocular hypertension and open-angle glaucoma. It designed to target the natural aqueous humor outflow pathways. The unique design of the device enables the performance of two distinct functions in a single unified step: creation of incisions in the trabecular meshwork and direct delivery of viscoelastic agent into Schlemm's canal. The optimized version of Streamline Surgical System is equipped with a transparent tip to enhance visualization of key anatomical structures throughout the procedure. Additionally, the proprietary ClickPulse technology provides controlled, targeted delivery of the viscoelastic substance with a single button press [61, 62, 63].

Figure 10. *OMNI Surgical System*

The **OMNI® Surgical System** (Sight Sciences, USA) (**Fig. 10**) is an implant-free, minimally invasive technology Indicated for canaloplasty (microcatheterisation and transluminal viscolidation of Schlemm's canal) followed by trabeculotomy. This procedure comprehensivly restores the outflow by addressing all three main resistance points: TM, Schlemm's canal and distal collector channels. The first step is the microcatheterization of SC up to 360°, followed by transluminal viscodilation to dilate and clear the canal and collector channels. Second step – trabeculotomy – cutting the TM to enhance direct outflow. This hybrid approach makes OMNI unique among other MIGS as it targets multiple resistance points. Some authors state the significant reduction in IOP of 41% and IOP-lowering drops in 85% [64–67].

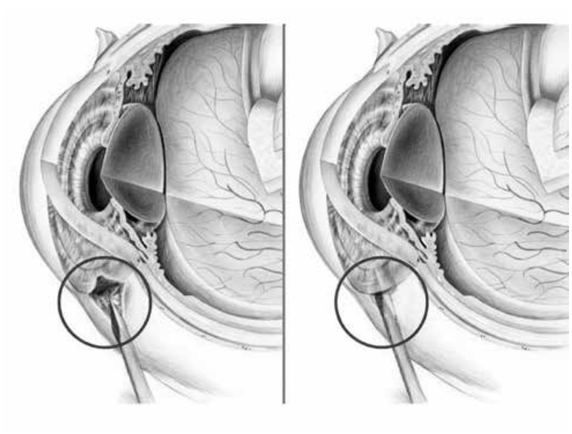

Figure 11. *Canaloplasty: ab externo vs ab interno*

Another group of MIGS without device is Schlemm's canal and collector channel targeting procedures – canaloplasty and viscodilation - usually implements to expand/ dilate Schlemm's canal, to break adhesions, to stretch the TM and to improve flow into distal collector channels without removing tissue (Fig. 11). Canaloplasty first was introduced by for glaucoma treatment in the late 2000s by Prof. Robert Stegmann (Medical University of South Africa) in 1999, world's first canaloplasty (ab externo technique) for glaucoma treatment was performed by him in 2004. Then, in the late 2000s it was invented in USA by Dr Lewis and colleaugues. It was ab externo procedure when the catheter inserts into the SC followed by the placement of a tight suture to widen the canal lumen. This classic ab externo procedure is not considered as a MIGS. But its modifications performed ab interno have been classified as MIGS and were introduced by Dr Mahmoud Khaimi (Dean McGee Eye Institute, USA) and Dr Marc Gallardo (El Paso Eye Surgeons, USA). There are several modifications of this procedure: mini-canaloplasty, catheterless canaloplasty, canaloplasty with a Galucolight catheter, canaloplasty with suprachoroidal drainage. Can be done with or without viscodilation, with or without the placement of a suture, standalone or combined with the cataract surgery [68–76].

ABiC (Ab Interno Canaloplasty) is an improved version of the traditional Ab Externo Canaloplasty procedure developed by Dr Michael J. Gallardo, MD. Its disingishing feature is the absence of a tension suture inserted into the Schlemm's canal lumen. Ab Interno Canaloplasty eliminates manipulation of the conjunctiva and sclera. A temporal corneal incision is used to insert the flexible, illuminated microcatheter (like iTrack or iTrack Advance) into SC. The microcatheter, with its red tip illumination, allows for effective monitoring of the tip's position within the drainage system. After 360° of microcatheter insertion, it is gradually withdrawn while simultaneously injecting viscoelastic into the canal lumen. The viscoelastic injected into the SC dilates the canal lumen, eliminates trabecular deflections caused by high IOP, opens the SCX, and dilates the collecting channels, thereby also affecting the distal outflow system. Effective not only for POAG/OAG, but also for pigmentary and pseudoexfoliative glaucoma [77, 78, 79].

Figure 12. *iTrack®/iTrack® Advance*

iTrack®/iTrack® Advance (Glaukos Corporation, USA) (**Fig. 12**) – is a microcatheter designed for canaloplasty, firstly introduced in 2008 in accordance with the scientific work of Prof. Robert Stegmann and Dr. Murray Johnstone. A flexible yet sufficiently rigid internal guidewire allows precise maneuvering within narrow segments of Schlemm's canal and enables complete circumferential (360°) catheterization through a single intubation. The device allows individualized regulation of the volume of viscoelastic material delivered for each patient and passages the viscoelastic into Schlemm's canal via a patented pressure-controlled delivery mechanism. Fiber-optic illumination at the distal tip of the microcatheter provides predictable and controlled movement through the canal, minimizing the risk of misdirection into the suprachoroidal space or the collector channels. The procedure is performed without excision or damage to ocular tissues, thereby minimizing the likelihood of postoperative inflammatory response [80–88].

Visco® 360 Viscosurgical System (Sight Sciences, Inc., USA) is a single-use surgical device designed to restore physiological outflow of aqueous humor in patients with open-angle glaucoma and hypertension. The device received CE-approval in 2015 and was commercially launched in 2018. A soft, flexible microcatheter with an atraumatic tip anables catheterization without drainage system's tissue destruction, while the automated delivery of a preset volume of viscoelastic ensures controlled dilation of Schlemm's canal and collector channels [64, 79].

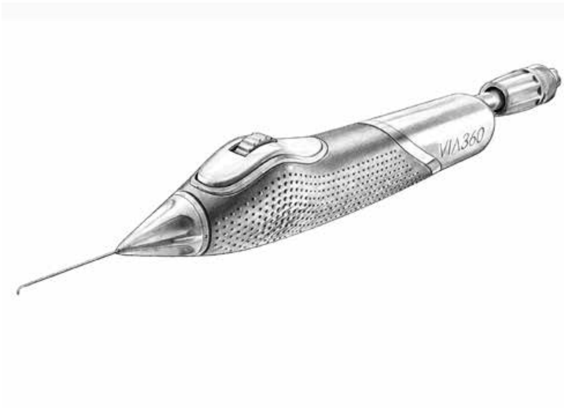

Figure 13. *Via 360® Surgical System*

Via 360® Surgical System (New World Medical Corporation, USA) (**Fig. 13**) – is an advanced device designed to deliver viscoelastic ophthalmic material into the natural drainage pathway – Schlemm's canal – to dilate it, improving aqueous humor outflow and reducing IOP. The device's microcatheter has a unique design that allows for 360° advancement and the microchannels are configured to deliver the viscoelastic both forward and tangentially, ensuring its delivery to target areas. The rotating cannula used in this technology provides improved positioning and flexibility during single insertion without the need for full rotation of the device.

iPrime Viscodelivery System (Glaukos Corporaton) – is a single-use, sterile system for minimally invasive glaucoma surgery developed by Glaukos and received the

FDA approval in 2022. The device is used in procedures involving dilation of the eye drainage system by injecting viscoelastic into the Schlemm's canal. Controlled catheter advancement and adjustable cannula angle allow for targeting various areas of resistance. An optimized viscoelastic delivery system ensures targeted, controlled, and dosed administration [84].

Another type of device-free MIGS with completely different action mechanism is the procedure lowers IOP by reducing aqueous humor production.

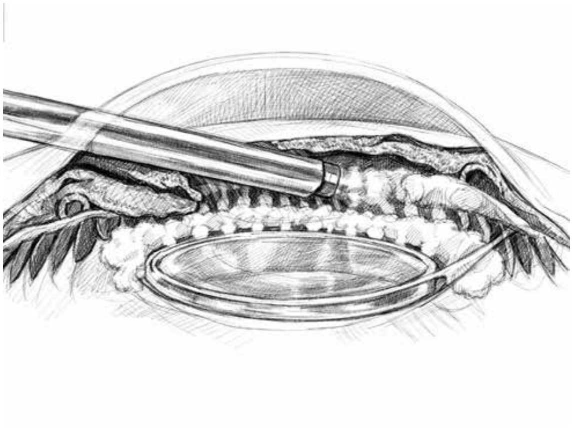

Figure 14. *ECP (Endoscopic Cyclophotocoagulation)*

Endoscopic Cyclophotocoagulation (ECP) was developed by American ophthalmologist Dr Martin Uram in early 1990th and can be considered as the device-free **MIGS (Fig.14)**. Since then, the equipment has been improved, and the procedure currently involves the use of a probe inserted through a limbal incision and exposure of the ciliary processes to a low-power laser (usually 819 nm) in the middle and posterior thirds. Hypotensive effect is achieved by suppressing aqueous humor production, contracting the ciliary processes, lifting the iris root, and opening the anterior chamber angle. Direct visualization of the laser allows for a more targeted approach while minimizing damage to the ciliary muscles and stroma. It uses an endoscopic probe with built-in laser, camera, and light, to directly visualize and precisely ablate the ciliary processes, reducing aqueous humor production. The direct visualization allows to provide very careful and controlled treatment with minimum damage of nearby structures [19, 85].

Narrative review of meta-analysis.

As we mentioned above, there are a lot of studies dedicated to MIGS, their advantages and disadvantages, techniques and risks, efficacy and complications. In this review we would like to present the results of latest large international multicenter meta-analysis of MIGS results. Thus, typically refers to comprehensive research studies that combine data from multiple clinical centers and trials to evaluate the common information in managing of glaucoma. This improves the accuracy of conclusions about treatment efficacy, safety and risk factors as well as highlights the common situation with MIGS treatment modality in the world.

In retrospective meta-analysis study done by Wu K.Y. and colleagues, evaluated the safety and effectiveness of two biomimetic surgeries: Kahook Dual Blade Goniotomy and Trabecular Micro-Bypass Stent in combination with cataract extraction. Study included 176 eyes (110 patients): 142 eyes in the iStent group and 34 in the KDB group. 20% reduction in IOP (67%) and a higher proportion of patients reaching an IOP of less than 19 mmHg (81%) was achieved in iStent inject patients instead of 50% and 71% subsequently in KDB patients The number of medications did not decrease in either group. The KDB group had more failures (29.4% vs. 4.2%) and a significantly higher adverse event rate than the iStent inject group (47.1% vs 12.0%) [86].

In another meta-analysis, performed by Mora-Paez D.J. et al., 14 studies were included with a total of 1959 eyes (958 phaco-KDB, and 1000 phaco-Stent including 753 phaco-iStent and 207 phaco-iStent inject). Kahook dual blade (KDB) goniotomy achieved higher rates of surgical success compared with iStent/iStent inject implantation combined with phacoemulsification (odds ratio: 0.68; 95% CI: 0.50 to 0.92; P = 0.01; I2 = 40%). KDB goniotomy demonstrated better intraocular pressure (IOP) reduction at month 6 compared with the stent group (MD: 1.13 mm Hg; 95% CI: 0.43 to 1.83; P = 0.002; I2 = 51%). Medication reduction and the incidence of adverse events were comparable between groups [87].

This retrospective observational study hold by Beres H. and co-authors included 85 patients with POAG and PEXG who underwent canaloplasty (group 1) or phacocanaloplasty (group 2). In group 1, the mean baseline intraocular pressure (IOP) of 22.1 ± 0.9 mmHg was reduced to 15.3 ± 0.5 mmHg, 15.7 ± 0.5 mmHg, and 15.9 ± 0.7 mmHg at 1, 5, and 10 years, respectively. The mean medication use decreased from 2.4 ± 1.0 before surgery to 0.1 ± 0.5, 0.8 ± 1.1, and 1.4 ±1.3 at 1,5, and 10 years, respectively. In group 2, IOP was reduced from 20.4 ± 1.5 to 15.6 ± 1.0, 14.3 ± 0.8, and 14.2 ± 1.2 at 1, 5, and 10 years, respectively. The mean medication use dropped from 2.4 ± 1 to 0.3 ± 0.9, 0.9 ± 1.4, and 0.8 ± 1.1 at 1, 5, and 10 years, respectively. Additional surgery was performed postoperatively in nine cases (13.9%) within the initial 3 months. Patients with PEXG had a significantly higher requiring re-operation (HR = 5.11, HR = 5.11, 95% CI 1.05–24.74, p = 0.043). No serious complications were observed [88].

The meta-analysis performed by Oo H.H. et al. quantitatively examined the efficacy of angle-based minimally invasive glaucoma surgery (MIGS) in normal tension glaucoma (NTG). 15 studies with a pooled total of 367 eyes which underwent combined phacoemulsification and angle-based MIGS were included for final meta-analysis. Pilot, cohort, observational studies and randomized controlled trials for trabecular-bypass devices, excisional trabeculotomy, goniotomy and ab-interno canaloplasty with or without cataract surgery were included. There was significant reduction in both IOP and AGM post-operatively at 6 months (2.44 mmHg, 95%CI: 1.83-3.06; 1.21 AGM, 95%CI: 0.99-1.44), 12 months (2.28 mmHg, 95%CI: 1.71-2.84; 1.18 AGM, 95%CI: 0.90-1.47), 24 months (2.10 mmHg, 95%CI: 1.51-2.68; 1.26 AGM, 95%CI: 0.85-1.68) and 36 months (2.43 mmHg, 95%CI: 1.71-3.15, 0.87 AGM, 95%CI: 0.21-1.53) (all p < 0.05). Subgroup analysis on combined phacoemulsification-iStent inject surgery demonstrated a reduction in both IOP (2.31 mmHg, 95%CI: 1.07-3.56, p < 0.001) and AGM (1.07 AGM, 95%CI: 0.86-1.29, p < 0.001) at 12 months post-operatively. It was concluded, that angle-based MIGS standalone or combined with phacoemulsification effectively reduces IOP and AGM in NTG eyes for up to 36 months after surgery [89].

Systematic literature review and meta-analysis were conducted by Dr Zu Y. and colleagues to assess the effectiveness of MIGS as monotherapy and in combination with phacoemulsification in the management of NTG. A total of 11 studies involving 413 eyes from 327 NTG patients were included and followed-up from 6 to 60 months. MIGS alone reduced IOP by 2.62 mmHg (95% CI: -3.70 to -1.54; Z = 4.77, P < 0.00001), while MIGS with cataract surgery reduced IOP by 2.09 mmHg (95% CI: -2.83 to -1.35; Z = 5.53, P < 0.00001). The number of IOP-lowering medications decreased by 1.47 with MIGS alone (95% CI: -2.16 to -0.77; Z = 4.07, P < 0.0001) and by 1.13 with combined surgery (95% CI: -1.75 to -0.52; Z = 3.63, P = 0.0003). No significant differences were observed between the two surgical approaches. This meta-analysis also demonstrated that either MIGS alone or combined with phacoemulsification effectively reduced the IOP and the requirement for IOP-lowering medications in NTG patients [90].

The scientific group headed by Dr Yuan P.H.S. conducted the systematic review and meta-analysis to compare efficacies and safeties of combined phacoemulsification-microinvasive glaucoma surgeries (MIGS) to phacoemulsification only in eyes with OAG. MIGS were grouped according to mechanisms of action: TM bypass that improves aqueous drainage into Schlemm's canal, non-GATT goniotomies that remove TM with varying devices, and GATT that removes TM with a catheter or suture placed into Schlemm's canal. Efficacy was measured by reductions in IOP and medications, whereas safety was compared using incidence of sight-threatening and other adverse events. A total of 95 studies were included, accounting for 9733 eyes followed up at 1-year. The control group had a baseline IOP of 16.9 (95% CI: 15.9-17.9) mm Hg on 1.43 (1.19-1.68) medications and a postoperative IOP of 15.2 (14.4-15.9) mm Hg on 0.80 (0.54-1.00) medications. The TM bypass baseline IOP was 18.2 (17.6-18.7) mm Hg on 1.89 (1.78-2.01) medications that lowered to an IOP of 14.8 (14.5-15.1) mm Hg on 0.80 (0.65-0.95) medications at 1 year after operation. The non-GATT goniotomy baseline IOP was 20.0 (19.2-20.8) mm Hg on 2.30 (2.09-2.53) medications, and at 1-year follow-up, the IOP was 14.6 (14.3-15.0) mm Hg on 1.41 (1.22-1.62) medications. Lastly, the GATT baseline IOP of 21.8 (19.5-24.1) mm Hg on 2.90 (2.36-3.44) medications was reduced to an IOP of 12.5 (10.0-15.0) mm Hg on 0.73 (0.37-1.09) medications at 1-year after operation. All MIGS groups had equal or lower rates of sight-threatening events and secondary glaucoma surgery when compared with control. GATT had the highest hyphema rate at 27.7% (13.5%-44.5%) followed by non-GATT goniotomy with 15.5% (7.8%-25.0%). These were both significantly higher than TM bypass and control groups, with hyphema rates of 3.5% (1.6%-5.9%) and 4% (only 1 study reporting hyphema rate), respectively. The study evidences that combined phacoemulsification-MIGS is beneficial for patients with open-angle glaucoma and does not increase the incidence of vision-threatening events [91].

The systematic review and meta-analysis done by Drs Zhang B., Kang J., Chen X. studied the efficiency and safety of canaloplasty (CP) and compared the outcomes between CP and trabeculectomy (TE). In the meta-analysis, IOP decreased by 9.94 (95% CI 8.42 to 11.45) mmHg with an average AGM reduction of 2.11 (95% CI 1.80 to 2.42) one year after CP. The IOP reduction was significantly higher after TE than after CP, with an average difference of 3.61 (95% CI 1.69 to 5.53) mmHg at 12 months post operationally. For complications, the incidence of hyphema was significantly higher in CP and the Descemet membrane detachment was just reported in CP, with an incidence of 3%. However, the incidence of hypotony and choroidal effusion/ detachment was significantly lower in CP. Meanwhile, suprachoroidal hemorrhage and bleb needling were only reported in TE. The authors conclude CP was less effective in IOP reduction than TE, but CP was able to achieve similar postoperative success rates and reduce the number of AGMs likewise. CP was also associated with lower incidence of complications [92].

The Meta-Analysis and Systematic Review performed by Dr Benjamin Paik and colleagues analyzed the safety and efficacy of MIGS in lowering IOP and medication burden in Primary Angle Closure (PAC) and Primary Angle Closure Glaucoma (PACG). Review includes 23 studies of 875 patients, however the meta-analysis -15 studies of 590 patients. MIGS with and without phacoemulsification) demonstrated mean reduction in IOP of 7.71 mmHg (95% CI: 5.16-10.26), and in medication of 1.57 (95% CI: 1.17-1.96) at 1 year. As MIGS procedure are not often used when angle closure due to iridotrabecular contact, access to the TM can be established with cataract removal/goniosynechiolysis. In that eye conditions MIGS-phaco as the combined procedure demonstrates a significant advantage over standalone phacoemulsification: WMD 0.59, 95% CI: -0.04-1.22 in reducing medication burden and WMD (weighted mean differences) 1.22; 95% CI: -0.96-3.39 in IOP-lowering up till 1 year. Overall complication rate was 141/875 (16%). According to this, authors conclude that MIGS brings the sustained IOP and medication burden reduction alongside with the favourable safety-profile in AC eyes, and MIGS-phaco may be more preferable to standalone phacoemulsification [93].

A literature review study done by Dr Cwiklinska-Haszcz A. was dedicated to safety profile analysis of different types of canaloplasty and GATT with and without phacoemulsification. It showed the most common complication as hyphema and microhyphema (5-70% in canaloplasty group and 23-100% in GATT group. Other complications (elevated IOP, Descemet's membrane detachment, iritis or hypotony in canaloplasty group were observed in 10% cases, GATT group below 3.1% were iridodialysis or cyclodialysis, hemorrhages to vitreous and suprachoroidal space [94].

Meta-analysis performed by Dr Zhu and colleagues were performed to calculate the IOP and topical medications changes following treatment at 1-, 6-, 12-, 24-months follow-up. Five studies with 290 eyes at baseline were included. At the 1-month follow-up, there was a significant mean IOP reduction of 7.40 mm Hg following standalone OMNI (MD=-7.40; 95% CI: -10.61 to -4.20; P < 0.0001). At the 6-month follow-up, mean IOP reduction was 7.25 mm Hg (MD =-7.25; 95% CI: -9.60 to -4.89; P < 0.0001). At the 1-year follow-up, mean IOP reduction was 7.49 mm Hg (MD=-7.49; 95% CI: -9.47 to -5.50; P < 0.0001). At 2-year follow-up, mean IOP reduction was 8.77 mm Hg (MD =-8.77; 95% CI: -10.35 to -7.19; P <0.0001). In addition, at the 1-year follow-up, mean reduction of topical medications was 0.77 (MD =-0.77; 95% CI: -1.44 to -0.09; P = 0.025), and 46.2% of patients were medication-free (95% CI: 35.6%-57.2%). They concluded, that OMNI Surgical System is an effective standalone procedure for canaloplasty and trabeculotomy in OAG patients and led to a significant reduction in IOP at multiple time points and medication burden [95].

Conclusion

Microinvasive glaucoma surgery is developing rapidly. Device-free part of this treatment modality can become a first-choice surgery for early-stage glaucoma cases due to its physiological approach: enhancing aqueous humor natural pathway and absence of implant/stent. Among other advantages: absence of scarring, which leaves the possibility for subsequent surgeries in case of decompensation of glaucoma process; high safety profile caused by ab-interno approach; cost-effectiveness; wild specter of using (OAG, PXG, PG, ACG); can be done standalone or combined with routine cataract surgery.

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REFERENCE

1. Allison, K. Epidemiology of Glaucoma: The Past, Present, and Predictions for the Future / K.Allison, D.Patel, O.Alabi // Cureus, – 2020. 12(11), – p. 11686. https://doi.org/10.7759/cureus.11686
2. GBD 2019 Blindness and Vision Impairment Collaborators on behalf of the Vision Loss Expert Group of the Global Burden of Disease Study (VLEG-GBD) Causes of blindness and vision impairment in 2020 and trends over 30 years, and revalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study // Lancet Glb. Health, – 2021. 9, – p. 144-160. https://doi.org/10.1016/S2214-109X(20)30489-7
3. Burton, M.J. The Lancet Global Health Commission on Global Eye Health: vision beyond 2020 / M.J.Burton, J.Ramke, A.P.Marques [et al.] // Lancet Glob. Health, – 2021. 9(4), – p. 489-551. https://doi.org/10.1016/S2214-109X(20)30488-5
4. Zhang, N. Prevalence of primary open angle glaucoma in the last 20 years: a meta-analysis and systematic review / N.Zhang, J.Wang, Y.Li [et al.] // Sci. Rep., – 2021. 11(1), – p. 13762. https://doi.org/10.1038/s41598-021-92971-w
5. Chan, E.W. Glaucoma in Asia: regional prevalence variations and future projections / E.W.Chan, X.Li, Y.C.Tham [et al.] // Br. J. Ophthalmol., – 2016. 100(1), – p. 78-85. https://doi.org/10.1136/bjophthalmol-2014-306102
6. Gallo Afflitto, G. Primary Open Angle Glaucoma Prevalence in Europe: A Systematic Review and Meta-Analysis / G.Gallo Afflitto, F.Aiello, M.Cesareo [et al.] // J. Glaucoma, – 2022. 31(10), – p. 783-788. https://doi.org/10.1097/IJG.0000000000002083
7. Li, R. Global tendency and research trends of minimally invasive surgery for glaucoma from 1992 to 2023: A visual bibliometric analysis / R.Li, H.Liu, K.Zhang [et al.] // Heliyon, – 2024. 10(16), – p. 36591. https://doi.org/10.1016/j.heliyon.2024.e36591
8. López-Muñoz, F. A bibliometric and mapping analysis of glaucoma research between 1900 and 2019 / F.López-Muñoz, R.N.Weinreb, S.Moghimi [et al.] // Ophthalmol. Glaucoma, – 2021. 5(1), – p. 16-25. https://doi.org/10.1016/j.ogla.2021.05.008
9. Ma, A.K. GlaucoMap – Distribution of Glaucoma Surgical Procedures in the United States / A.K.Ma, J.H.Lee, J.L.Warren [et al.] // Clin. Ophthalmol., – 2020. 14, – p. 2551-2560. https://doi.org/10.2147/OPTH.S257361
10. Luebke, J. Trends in surgical glaucoma treatment in Germany between 2006 and 2018 / J.Luebke, D.Boehringer, A.Anton [et al.] // Clin. Epidemiol., – 2021. 13, – p. 581-592. https://doi.org/10.2147/CLEP.S310542
11. Iwasaki, K. Clinical Practice Preferences for Glaucoma Surgery in Japan in 2024 / K.Iwasaki, S.Arimura, Y.Takamura [et al.] // J. Clin. Med., – 2025. 14(6), – p. 2039. https://doi.org/10.3390/jcm14062039
12. Aghayeva, F. Glaucoma care and surgical management in Azerbaijan // Acta. Ophthalmologica, – p. 2024. 102, – p. 279. https://doi.org/10.1111/aos.16437
13. Касимов, Э.М. К изучению современных эпидемиологических особенностей распространения глаукомы в Азербайджане / Э.М.Касимов, Р.Б.Агаева, Н.М.Рустамова [и др.] // Азербайджанский Офтальмологический Журнал, – 2022. 3(42), – p. 51-57.
14. Russia Glaucoma Surgery Devices Market Revenue, Production, Consumption, Average Price // Import vs Export, www.datavagyanik.com
15. https://www.market-scope.com/pages/reports/520/2025-glaucoma-surgical-device-market-report-global-analysis-for-2025-to-2030-august-2025#reports
16. Premarket Studies of Implantable Minimally Invasive Glaucoma Surgical (MIGS) Devices // Center for Devices and Radiological Health, Food and Drug Administration, – 2015.
17. European Glaucoma Society Terminology and Guidelines for Glaucoma, 5th Edition // Br. J. Ophthalmol., – 2021. 105(1), – p. 1-169. https://doi.org/10.1136/bjophthalmol-2021-egsguidelines
18. Dhawale, K.K. A Comprehensive Review of Recent Advances in Minimally Invasive Glaucoma Surgery: Current Trends and Future Directions / K.K.Dhawale, P.Tidake // Cureus, – 2024. 16(7), – p. 65236. https://doi.org/10.7759/cureus.65236
19. Chan, P.P.M. Minimally Invasive Glaucoma Surgery: Latest Developments and Future Challenges / P.P.M.Chan, M.D.Larson, J.E.Dickerson Jr [et al.] // Asia Pac. J. Ophthalmol., – 2023. 12(6), – p. 537-564. https://doi.org/10.1097/APO.0000000000000646
20. Gurnani, B. Minimally Invasive Glaucoma Surgery / B.Gurnani, K.Tripathy // StatPearls, – 2025.

21. Garg, A. Comprehensive study of traditional glaucoma drainage devices and emerging Micro Invasive Glaucoma Surgery (MIGS) devices: A review / A.Garg, G.Singh, Sh.Gupta [et al.] // Biomedical Engineering Advances, – 2025. 9, – p. 100140. https://doi.org/10.1016/j.bea.2024.100140
22. Gasimov, E.M. Drainage surgery in glaucoma treatment: past, present and future (literature review) / E.M.Gasimov, B.R.Babayeva, L.Sh.Bilandarli // Azerbaijan Journal of Ophthalmology, – 2025. 3(54), – p. 71-89. https://doi.org/10.71110/ajo791020251703547189
23. Richter, G.M. Minimally invasive glaucoma surgery: current status and future prospects / G.M.Richter, A.L.Coleman // Clin. Ophthalmol., – 2016. 10, – p. 189-206. https://doi.org/10.2147/OPTH.S80490
24. Ansari, A.S. Building consensus on MIGS: insights from a UKEGS survey / A.S.Ansari, A.J.Tatham, N.Amerasinghe [et al.] // Eye, – 2025. 39(11), – p. 2107-2109. https://doi.org/10.1038/s41433-025-03852-9
25. Carreon, T. Aqueous outflow – a continuum from trabecular meshwork to episcleral veins / T.Carreon, E.van der Merwe, R.L.Fellman [et al.] // Prog. Retin. Eye Res., – 2017. 57, – p. 108-133. https://doi.org/10.1016/j.preteyeres.2016.12.004
26. Johnson, M. What controls aqueous humour outflow resistance? // Exp. Eye Res., – 2006. 82(4), – p. 545-557. https://doi.org/10.1016/j.exer.2005.10.011
27. Finley, G.D. Kahook dual blade versus trabectome (KVT): comparing outcomes in combination with cataract surgery / G.D.Finley, E.Kim, M.Sarwana [et al.] // Clin. Ophthalmol., – 2023. 17, – p. 145-154. https://doi.org/10.2147/OPTH.S391527
28. Balas, M. Minimally Invasive Glaucoma Surgery: A Review of the Literature / M.Balas, D.J.Mathew // Vision, – 2023. 7(3), – p. 54. https://doi.org/10.3390/vision7030054
29. Kono, Y. Long-term clinical results of trabectome surgery in patients with open-angle glaucoma / Y.Kono, M.Kasahara, K.Hirasawa [et al.] // Graefes Arch. Exp. Ophthalmol., – 2020. 258(11), – p. 2467-2476. https://doi.org/10.1007/s00417-020-04897-0
30. Porter, M. Excisional Goniotomy in Latino Patients with Open-Angle Glaucoma: Outcomes Through 24 Months / M.Porter, A.Garza, M.Gallardo // Clin. Ophthalmol., – 2020. 14, – p. 3619-3625. https://doi.org/10.2147/OPTH.S271923
31. Sieck, E.G. Outcomes of Kahook dual blade goniotomy with and without phacoemulsification cataract surgery / E.G.Sieck, R.S.Epstein, J.B.Kennedy [et al.] // Ophthalmol. Glaucoma, – 2018. 1(1), – p. 75-81. https://doi.org/10.1016/j.ogla.2018.06.006
32. Bravetti, G.E. Surgical outcomes of excisional goniotomy using the Kahook dual blade in severe and refractory glaucoma: 12-month results / G.E.Bravetti, K.Gillmann, L.Salinas [et al.] // Eye, – 2023. 37(8), – p. 1608-1613. https://doi.org/10.1038/s41433-022-02196-y
33. Xie, Y., Qiao, C. Twelve-month outcomes of excisional goniotomy using the Kahook dual blade in advanced and refractory glaucoma // 11th World Glaucoma Congress. – Honolulu, – USA, – 2025. – p. 988.
34. Sugihara, K. Comparison of Standalone Tanito Microhook Trabeculotomy Between Unalateral and Bilateral Incision Groups / K.Sugihara, C.Ida, H.Ohtani [et al.] // J. Clin. Med., – 2025. 14(6), – p. 1976. https://doi.org/10.3390/jcm14061976
35. Sasidharan, A. Short-term outcomes of Tanito microhook ab interno trabeculotomy combined with phacoemulsification in primary open-angle glaucoma – A pilot study / A.Sasidharan, P.Shah, M.Thulasidas // Indian J. Ophthalmol., – 2025. 73(2), – p. 250-253. https://doi.org/10.4103/IJO.IJO_723_24
36. Pillai, M.R., Maheswari, D., Nagdev, N. Comparison of 360 degree gonioscopy-assisted trasluminal trabeculotomy vs 180 degree Tanito microhook trabeculotomy with phaco in open angle glaucoma // 11th World Glaucoma Congress. – Honolulu, – USA, – 2025. – p. 952.
37. Ramjiani, V. Sampling trabecular meshwork using TrabEx+ / V.Ramjiani, H.S.Mudhar, T.Julian [et al.] // BMC Ophthalmology, – 2021. 21(1), – p. 138. https://doi.org/10.1186/s12886-021-01895-6
38. Gourgouli, I. Results of Minimally Invasive Device TrabEx+ in Patients with Primary Open Angled Glaucoma / I.Gourgouli, S.Spai, K.A.A.Douglas [et al.] // Journal Ophthalmol., Adv. Res., – 2022. 3(2), – p. 1-8. https://doi.org/10.46889/JOAR.2022.3202
39. Gosling, D. Early Results of Irrigating Goniectomy With TrabEx+: A Novel Device for the Treatment of Open-angle Glaucoma / D.Gosling, H.Wang, G.Auger // J. Glaucoma, – 2022. 31(4), – p. 268-273. https://doi.org/10.1097/IJG.0000000000001994
40. Areaux, R.G.Jr. Trabeculotomy Ab Interno With the Trab360 Device for Childhood Glaucomas / R.G.Jr. Areaux, A.L.Grajewski, S.Balasubramaniam [et al.] // Am. J. Ophthalmol., – 2020. 209, – p. 178-186. https://doi.org/10.1016/j.ajo.2019.10.014
41. Meshksar, A. Ab-interno Trabeculotomy Procedures: A Review / A.Meshksar, M.R.Razeghinejhad, A.Azimi // J. Curr. Ophthalmol., – 2023. 35(2), – p. 110-124. https://doi.org/10.4103/joco.joco_45_23

42. Ammar, D.A. Preclinical Investigation of Ab Interno Goniotomy Using Three Different Techniques / D.A.Ammar, E.Porteous, M.Y.Kahook // Clin. Ophthalmol., – 2023. 17, – p. 2619-2623. https://doi.org/10.2147/OPTH.S424977
43. Mokhashi, N. Patterson, I., Qiu, M. Safety and efficacy of resident-performed SION goniotomy at the time of cataract surgery // ARVO Annual Meeting. – Seattle, – May 5-9, – 2024.
44. Grover, D.S. Gonioscopy-assisted transluminal trabeculotomy, ab interno trabeculotomy: technique report and preliminary results / D.S.Grover, D.G.Godfrey, O.Smith [et al.] Ophthalmology, – 2014. 121(4), – p. 855-861. https://doi.org/10.1016/j.ophtha.2013.11.001
45. Wan, Y. Gonioscopy-assisted Transluminal Trabeculotomy (GATT) combined phacoemulsification surgery: Outcomes at a 2-year follow-up / Y.Wan, K.Cao, J.Wang [et al.] // Eye, – 2023. 37, – p. 1258-1263. https://doi.org/10.1038/s41433-022-02087-2
46. Bhartiya, S. Is GATT the Answer? / S.Bhartiya, Z.Aktas, P.Ichhpujani // J. Curr. Glaucoma Pract., – 2023. 17(4), – p. 167-168. https://doi.org/10.5005/jp-journals-10078-1425
47. Cwiklinska-Haszcz, A. The Efficacy and Safety of the GATT Procedure in Open-Angle Glaucoma – 6-Month Results / A.Cwiklinska-Haszcz, T.Zarnowski, D.Wrobel-Dudzinska [et al.] // Int. J. Environ. Res. Public. Health, – 2023. 20(3), – p. 2759. https://doi.org/10.3390/ijerph20032759
48. Aktas, Z. Surgical outcomes of prolene gonioscopy-assisted transluminal trabeculotomy in patients with moderate to advanced open angle glaucoma / Z.Aktas, A.Y.Ucgul, C.Bektas [et al.] // J. Glaucoma, – 2019. 28(10), – p. 884-888. https://doi.org/10.1097/IJG.0000000000001331
49. Kader, M., Pillai, M., Prabhakaran, S. [et al.] Outcomes of combined phacoemulsification with GATT versus phacoemulsification with trabeculectomy in primary angle closure glaucoma (PACG) // 11th World Glaucoma Congress. – Honolulu, – USA, – 2025. – p. 919.
50. Gallardo, M.J. iAccess: Efficacy and Safety of Pairing iStent Inject Trabecular Micro-Bypass and iAccess Precision Blade Goniotomy in Patients with Open-Angle Glaucoma / M.J.Gallardo, M.Porter // Ophthalmol. Ther., – 2023. 12(4), – p. 1973-1987. https://doi.org/10.1007/s40123-023-00726-9
51. Qiu, M. Clinical Outcomes and Safety Profile of Standalone Canaloplasty Vs. Canaloplasty Combined with Cataract Surgery Using Itrack Microcatheter / M.Qiu, D.Lubeck, K.Barton [et al.] // Invest Ophthalmol. Vis. Sci., – 2025. 66(8), – p. 5090.
52. Ayub, G. Bent Ab Interno Needle Goniotomy Versus Gonioscopy-Assisted Transluminal Trabeculotomy in Primary Open Angle Glaucoma: A Randomized Clinical Trial / G.Ayub, V.P.Costa // J. Glaucoma, – 2025. 34(11), – p. 924-932. https://doi.org/10.1097/IJG.0000000000002629
53. Van Wyk, S.H. Outcomes of bent ab interno needle goniectomy in a regional eye hospital in South Africa / S.H.Van Wyk, M.Du Bruyn, N.T.Mathe [et al.] // Afr. Vision Eye Health, – 2025. 84(1), – p. 1-5. https://doi.org/10.4102/aveh.v84i1.999
54. Aktaş, Z. Ab Interno Goniotomy/Goniectomy Techniques / Z.Aktaş, S.Dorairaj, M.Sayed [et al.] // Turk J. Ophthalmol., – 2025. 55(3), – p. 159-170. https://doi.org/10.4274/tjo.galenos.2025.29345
55. Raj, S., Agarwal, S., Pandav, S. [et al.] Prospective RCT of Bent Ab Interno Needle Goniectomy Versus Conservative Treatment for Evaluation of IOP, AGM and QOL in POAG patients // 11th World Glaucoma Congress. – Honolulu, – USA, – 2025.
56. Tokumo, K. One-year Outcomes of Gonio Scratch as a Minimally Invasive Glaucoma Surgery With Cataract Removal / K.Tokumo, M.Yokoyama, T.Baba [et al.] // J. Glaucoma, – 2025. 34(6), – p. 468-475. https://doi.org/10.1097/IJG.0000000000002563
57. Tokumo, K. The gonio scratch study: methodology of a multicenter clinical trial establishing a new minimally invasive glaucoma surgery / K.Tokumo, N.Okada, T.Mochizuki [et al.] // Nagoya J. Med. Sci., – 2024. 86(1), – p. 36-42. https://doi.org/10.18999/nagjms.86.1.36
58. Durr, G.M. Current review of Excimer Laser Trabeculostomy / G.M.Durr, M.Töteberg- Harms, R.Lewis [et al.] // Eye Vis. (Lond), – 2020. 7, – p. 24. https://doi.org/10.1186/s40662-020-00190-7
59. Moreno-Valladares, A. Combined excimer laser trabeculostomy and phacoemulsification: One year follow-up real world data of a laser-based MIGS / A.Moreno-Valladares, N.P.Amorós, M.M.Llatas [et al.] // Arch. Soc. Esp. Oftalmol. (Engl Ed), – 2021. 96(12), – p. 631-639. https://doi.org/10.1016/j.oftale.2020.12.004
60. Aghayeva, F., Assaf, A., Lanzl, I. Cataract surgery combined with excimer laser trabeculostomy versus cataract surgery alone in patients with open-angle glaucoma // 11th World Glaucoma Congress. – Honolulu, – USA, – 2025. – p. 990.
61. Lazcano-Gomez, G. Interim Analysis of STREAMLINE Surgical System Clinical Outcomes in Eyes with Glaucoma / G.Lazcano-Gomez, S.J.Garg, E.Yeu [et al.] // Clin. Ophthalmol., – 2022. 16, – p. 1313-1320. https://doi.org/10.2147/OPTH.S358871

62. Sharma, M. Post-Operative Outcomes at One Year of STREAMLINE Microinvasive Glaucoma Surgery Combining Micro-Goniotomy and Focal Ab-Interno Canaloplasty / M.Sharma, C.Johnson, C.M.Carpenter [et al.] // Clin. Ophthalmol., – 2025. 19, – p. 3381-3387. https://doi.org/10.2147/OPTH.S532731
63. Seibold, L., Goldberg, D., Orlich, C. [et al.] 12-Month results of the Venice Randomized Controlled Trial comparing Streamline canaloplasty to iStent Inject W in primary open-angle glaucoma // 11th World Glaucoma Congress. – Honolulu, – USA, – 2025. – p. 920.
64. Ondrejka, S. 360° ab-interno Schlemm's canal viscolidation in primary open-angle glaucoma / S.Ondrejka, N.Körber // Clin. Ophthalmol., – 2019. 13, – p. 1235-1246. https://doi.org/10.2147/OPTH.S203917
65. Greenwood, M.D. 36-Month Outcomes from the Prospective GEMINI Study: Canaloplasty and Trabeculotomy Combined with Cataract Surgery for Patients with Primary Open-Angle Glaucoma / M.D.Greenwood, A.Yadgarov, B.E.Flowers [et al.] // Clin. Ophthalmol., – 2023. 17, – p. 3817-3824. https://doi.org/10.2147/OPTH.S446486
66. Yadgarov, A. Real-World Outcomes of Canaloplasty and Trabeculotomy Combined with Cataract Surgery in Eyes with All Stages of Open-Angle Glaucoma / A.Yadgarov, K.Dentice, Q.Aljabi // Clin. Ophthalmol., – 2023. 17, – p. 2609-2617. https://doi.org/10.2147/OPTH.S422132
67. Radcliffe, N.M. Standalone Canaloplasty and Trabeculotomy Using the OMNI Surgical System in Eyes with Primary Open-Angle Glaucoma: A 36-Month Analysis from the American Academy of Ophthalmology IRIS® Registry (Intelligent Research in Sight) / N.M.Radcliffe, J.Harris, K.Garcia [et al.] // Am. J. Ophthalmol., – 2025. 271, – p. 436-444. https://doi.org/10.1016/j.ajo.2024.12.015
68. Stegmann, R. Viscocanaloplasty for open-angle glaucoma in black African patients / R.Stegmann, A.Pienaar, D.Miller // Journal of Cataract & Refractive Surgery, – 1999. 25(3), – p. 316-322. https://doi.org/10.1016/s0886-3350(99)80078-9
69. Lewis, R.A. Canaloplasty: circumferential viscodilation and tensioning of Schlemm's canal using a flexible microcatheter for the treatment of open-angle glaucoma in adults: interim clinical study analysis / R.A.Lewis, K.von Wolff, M.Tetz [et al.] // J. Cataract. Refract. Surg., – 2007. 33(7), – p. 1217-1226. https://doi.org/10.1016/j.jcrs.2007.03.051
70. Khaimi, M.A. Minimally Invasive and Maximally Effective Glaucoma Treatment // J. Ophthalmol., – 2015. 2015, – p. 485065. https://doi.org/10.1155/2015/485065
71. Dickerson, J.E. Circumferential canal surgery: a brief history / J.E.Dickerson, R.H.Brown // Curr. Opin. Ophthalmol., – 2020. 31(2), – p. 139-146. https://doi.org/10.1097/ICU.0000000000000639
72. Гасанов, Д.В. Отдаленные результаты факоканалопластики при далекозашедшей псевдоэксфолиативной глаукоме и катаракте / Д.В.Гасанов, Э.М.Касимов // Вестник офтальмологии, – 2018. 134(3), – p. 28-33. https://doi.org/10.17116/oftalma2018134328
73. Hasanov, J.V. Phacocanaloplasty in patients with pseudoexfoliation glaucoma: six-year results // American Academy of Ophthalmology, – Chicago: – USA: – 2018. October; 27-30. – p. 124.
74. Babayeva, B., Kasimov, E., Bilandarli, L. [et al.] Phacocanaloplasty: advanced study. XXXVI Congress of the ESCRS // – Viena, – Austria, – 2018. – September 22-26, – p. 125.
75. Rękas, M. Mini-canaloplasty as a modified technique for the surgical treatment of open-angle glaucoma / M.Rękas, J.Konopinska, A.Byszewska [et al.] // Sci. Rep., – 2020. 10(1), – p. 12801. https://doi.org/10.1038/s41598-020-69261-y
76. Grieshaber, M.C. Flap-sparing canaloplasty: a modified approach to Schlemm's canal / M.C.Grieshaber, A.Pienaar, R.Stegmann // Graefes Arch. Clin. Exp. Ophthalmol., – 2019. 257(8), – p. 1729-1732. https://doi.org/10.1007/s00417-019-04329-8
77. Khaimi, M.A. A new MIGS on the block? / M.A.Khaimi, M.J.Gallardo // CRST, – 2015. 15(11), – p. 1-8.
78. Körber, N. Ab interno canaloplasty for the treatment of glaucoma: a case series study // Spektrum Augenheilkd., – 2018. 32(6), – p. 223-227. https://doi.org/10.1007/s00717-018-0416-7
79. Ondrejka, S. Long-term effect of canaloplasty on intraocular pressure and use of intraocular pressure-lowering medications in patients with open-angle glaucoma / S.Ondrejka, N.Korber, K.Dhamdhere // J. Cataract Refract Surg., – 2022. 48(12), – p. 1388-1393. https://doi.org/10.1097/j.jcrs.0000000000001000
80. Smith, S. Three Techniques for 360-degree gonioscopy-assisted transluminal trabeculotomy with iTrack advance / S.Smith, J.Wang, Sh.Kamat [et al.] // Am. J. Ophthalmol. Case Rep., – 2024. 36, – p. 102192. https://doi.org/10.1016/j.ajoc.2024.102192
81. Kicińska, A.K. Alternative application of an iTrack microcatheter and canaloplasty: case report and literature review / A.K.Kicińska, M.Rękas // Expert Opin. Drug. Deliv., – 2023. 20(9), – p. 1201-1208. https://doi.org/10.1080/17425247.2023.2256657

82. Chin, S. Reduction of intraocular pressure using a modified 360-degree suture trabeculotomy technique in primary and secondary open angle glaucoma / S.Chin, T.Nitta, Y.Shinmei [et al.] // J. Glaucoma, – 2012. 21(6), – p. 401-407. https://doi.org/10.1097/IJG.0b013e318218240c
83. Koerber, N., Ondrejka, S. 10-year efficacy and safety of iTrack ab-interno canaloplasty in primary open-angle glaucoma // 11th World Glaucoma Congress. – Honolulu, – USA, – 2025. – p. 950.
84. Afflitto, G.G. Minimally Invasive Glaucoma Surgery / G.G.Afflitto, S.S.Swaminathan // Int. Ophthalmol. Clin., – 2023. 63(4), – p. 33-60. https://doi.org/10.1097/IIO.0000000000000479
85. Falkenberry, S.M. Endocyclophotocoagulation / S.M.Falkenberry, C.J.Sienfried // Middle East Afr. J. Ophthalmol., – 2009. 16(3), – p. 130-133. https://doi.org/10.4103/0974-9233.56225
86. Wu, K.Y. Efficacy and Safety of Kahook Dual Blade Goniotomy and Trabecular Micro-Bypass Stent in Combination with Cataract Extraction / K.Y.Wu, S.Y.Qian, L.Houadj [et al.] // Biomimetics, – 2025. 10(10), – p. 691. https://doi.org/10.3390/biomimetics10100691
87. Mora-Paez, D.J. Kahook Dual Blade Goniotomy Versus iStent Implantation Combined With Phacoemulsification: A Systematic Review and Meta-Analysis / D.J.Mora-Paez, L.G.Cyrino, R.N.Louzada [et al.] // J. Glaucoma, – 2025. 34(3), – p. 232-247. https://doi.org/10.1097/IJG.0000000000002522
88. Beres, H. Ten-Year Results After Canaloplasty and Phacocanaloplasty / H.Beres, B.Gyarmati, S.Gurzu [et al.] // J. Clin. Med., – 2025. 14(7), – p. 2481. https://doi.org/10.3390/jcm14072481
89. Oo, H.H. Angle-based minimally invasive glaucoma surgery in normal tension glaucoma: A systematic review and meta-analysis / H.H.Oo, A.S.Y.Hong, S.Y.Lim [et al.] // Clin. Exp. Ophthalmol., – 2024. 52(7), – p. 740-760. https://doi.org/10.1111/ceo.14408
90. Yu, Z. Efficacy analysis of microinvasive glaucoma surgery alone or in combination with phacoemulsification in patients with normal tension glaucoma: a systematic review and meta-analysis / Z.Yu, M.Wu, Y.Tao [et al.] // BMC Ophthalmol., – 2025. 25(1), – p. 283. https://doi.org/10.1186/s12886-025-04104-w
91. Yuan, P.H.S. Combined Microinvasive Glaucoma Surgery With Phacoemulsification in Open-Angle Glaucoma: A Systematic Review and Meta-analysis / P.H.S.Yuan, M.Dorling, M.Shah [et al.] // Am. J. Ophthalmol., – 2025. 270, – p. 154-163. https://doi.org/10.1016/j.ajo.2024.07.034
92. Zhang, B. A System Review and Meta-Analysis of Canaloplasty Outcomes in Glaucoma Treatment in Comparison with Trabeculectomy / B.Zhang, J.Kang, X.Chen // J. Ophthalmol., – 2017. 2017, – p. 2723761. https://doi.org/10.1155/2017/2723761
93. Paik, B. Outcomes and Complications of Minimally Invasive Glaucoma Surgeries (MIGS) in Primary Angle Closure and Primary Angle Closure Glaucoma: A Systematic Review and Meta-Analysis / B.Paik, C.H.Chua, L.W.Yip [et al.] // Clin. Ophthalmol. – 2025. 19, – p. 483-506. https://doi.org/10.2147/OPTH.S505856
94. Cwiklinska-Haszcz, A. Revolution in glaucoma treatment: a review elucidating canaloplasty and gonioscopy-assisted transluminal trabeculotomy as modern surgical alternatives / A.Cwiklińska-Haszcz, K.Gołaszewska, T.Żarnowski // Front. Med., – 2025. March; 26. 12, – p. 1494391. https://doi.org/10.3389/fmed.2025.1494391
95. Zhu, D. Standalone Canaloplasty and Trabeculotomy Using the OMNI Surgical System in Patients With Open Angle Glaucoma: A Systematic Review and Meta-Analysis / D.Zhu, P.Shah, C.Zhang [et al.] // J. Glaucoma, – 2025. 34(11), – p. 949-958. https://doi.org/10.1097/IJG.0000000000002616