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MINIMALLY INVASIVE GLAUCOMA SURGICAL TECHNIQUES FOR OPEN-ANGLE GLAUCOMA : A SYSTEMATIC REVIEW

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ABSTRACT

Background: *Glaucoma affects more than 75 million people worldwide. Intraocular pressure (IOP)–lowering surgery is an important treatment for this disease. Interest in reducing surgical morbidity has led to the introduction of minimally invasive glaucoma surgeries (MIGS). Understanding the comparative effectiveness and safety of MIGS is necessary for clinicians and patients.*

Methods: *By comparing itself to the standards set by the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, this study was able to show that it met all of the requirements. So, the experts were able to make sure that the study was as up-to-date as it was possible to be. For this search approach, publications that came out between 2013 and 2023 were taken into account. Several different online reference sources, like Pubmed and SagePub, were used to do this. It was decided not to take into account review pieces, works that had already been published, or works that were only half done.*

Result: *In the PubMed database, the results of our search brought up 318 articles, whereas the results of our search on SagePub brought up 34 articles. The results of the search conducted for the last year of 2013 yielded a total 13 articles for PubMed and 12 articles for SagePub. In the end, we compiled a total of 5 papers, 4 of which came from PubMed and 1 of which came from SagePub. We included five research that met the criteria.*

Conclusion: *Although MIGS seem efficient in the reduction of the IOP and glaucoma medication and show good safety profile, this evidence is mainly derived from non-comparative studies and further, good quality RCTs are warranted.*

Keyword: *Minimally Invasive Glaucoma Surgery, Open-Angle Glaucoma*

INTRODUCTION

Glaucoma is the second commonest cause of blindness worldwide. To date, the main treatment for preventing glaucomatous damage consists in lowering intraocular pressure (IOP). The first ocular hypotensive approach is commonly eye-drop medications, whose instillation is often needed more than once per day. Poor compliance and tolerability can sometimes lead to treatment failure. Ab externo filtration surgery is still considered the gold standard but it is reserved to progressive disease and may lead to significant complications. Minimally-invasive glaucoma surgeries (MIGS) have been developed as safer and less traumatic surgical interventions for patients with mild to moderate glaucoma or who are intolerant to standard medical therapy. According to the commonly accepted definition, MIGS are surgical procedures with an ab-interno approach, minimal trauma with very little or no scleral dissection, minimal or no conjunctival manipulation, good safety profile and rapid recovery.[1]

Glaucoma is a family of diseases characterized by progressive, irreversible optic neuropathy and visual field loss. Recent estimates suggest that its most common form, open-angle glaucoma (OAG), affects more than 3% of people aged 40 years or older, and its global prevalence is expected to exceed 111 million cases by 2040. It behooves the international community of eyecare clinicians and vision researchers to seek and rigorously evaluate effective, well-tolerated treatments for this chronic condition.[2]

The only known modifiable risk factor for OAG is intraocular pressure (IOP), so IOP lowering is the mainstay of medical and surgical glaucoma therapy. In the past decade, there has been renewed interest in improving the success and safety profile of incisional glaucoma surgery. Traditional filtering surgeries, such as trabeculectomy and insertion of glaucoma drainage devices, place patients at risk for hypotony, diplopia, and infection. Minimally invasive glaucoma surgery (MIGS), also known as microincisional or microinvasive glaucoma surgery, refers to a diverse group of relatively new procedures that lower IOP with limited or no disruption to conjunctiva or sclera. Some of these procedures involve implantation of devices and all are readily combined with cataract extraction by phacoemulsification. MIGS may lower IOP to a more modest degree than traditional filtering surgeries but pose fewer risks to patients, so although they are not generally considered first-line therapy, MIGS have become widely used in standard glaucoma care. However, uncertainty persists about which MIGS are best for which patients. With applications in early glaucoma, MIGS are potentially relevant to an even larger pool of patients than are other glaucoma surgeries and warrant careful assessment.[3–5]

MIGS devices can be divided in: trabecular, suprachoroidal and subconjunctival based. They can be performed in association with cataract surgery or as a solo procedure.[6]

The trabecular based devices work by improving trabecular outflow through Schlemm's canal. The suprachoroidal based devices improve the uveoscleral outflow through a connection between the anterior chamber and the suprachoroidal space while the subconjunctival devices create an alternative outflow pathway of the aqueous humor to the subconjunctival space.[7]

There is a growing interest about MIGS procedures and several clinical studies have been published in the past years. This increase in surgical options should be supported by a clear evidence of their efficacy, to give the surgeon a detailed panorama on the potential surgical options.[7]

Many clinical studies have been small, nonrandomized and often lacking appropriate control arms. The purpose of this systematic review is to analyze available data on MIGS and to summarize and quantiy their effect on both intraocular pressure and use of tropical glaucoma medications as well as their safety profile.

METHODS

Protocol

By following the rules provided by Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, the author of this study made certain that it was up to par with the requirements. This is done to ensure that the conclusions drawn from the inquiry are accurate.

Criteria for Eligibility

For the purpose of this literature review, we review published literature compare effectiveness and safety of minimally invasive glaucoma. This is done to provide an explanation and improve the handling of treatment at the patient. As the main purpose of this paper, to show the relevance of the difficulties that have been identified as a whole.

In order for researchers to take part in the study, it was necessary for them to fulfil the following requirements: 1) The paper needs to be written in English. In order for the manuscript to be considered for publication, it needs to meet both of these requirements. 2) The studied papers include several that were published after 2013, but before the time period that this systematic review deems to be relevant. Examples of studies that are not permitted include editorials, submissions that do not have a DOI, review articles that have already been published, and entries that are essentially identical to journal papers that have already been published.

Search Strategy

We used "minimally invasive glaucoma surgery" and "open angle glaucoma" as keywords.The search for studies to be included in the systematic review was carried out using the PubMed and SagePub databases by inputting the words: *"minimally"[All Fields] AND ("invasibility"[All Fields] OR "invasible"[All Fields] OR "invasion"[All Fields] OR "invasions"[All Fields] OR "invasive"[All Fields] OR "invasively"[All Fields] OR "invasiveness"[All Fields] OR "invasives"[All Fields] OR "invasivity"[All Fields]) AND ("glaucoma"[MeSH Terms] OR "glaucoma"[All Fields] OR "glaucomas"[All Fields] OR "glaucoma s"[All Fields]) AND ("surgery"[MeSH Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "general surgery"[MeSH Terms] OR ("general"[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields] OR "surgery s"[All Fields] OR "surgerys"[All Fields] OR "surgeries"[All Fields]) AND ("glaucoma, open angle"[MeSH Terms] OR ("glaucoma"[All Fields] AND "open angle"[All Fields]) OR "open-angle glaucoma"[All Fields] OR ("open"[All Fields] AND "angle"[All Fields] AND "glaucoma"[All Fields]) OR "open angle glaucoma"[All Fields])* used in searching the literature.

Data retrieval

After reading the abstract and the title of each study, the writers performed an examination to determine whether or not the study satisfied the inclusion criteria. The writers then decided which previous research they wanted to utilise as sources for their article and selected those studies. After looking at a number of different research, which all seemed to point to the same trend, this conclusion was drawn. All submissions need to be written in English and can't have been seen anywhere else.

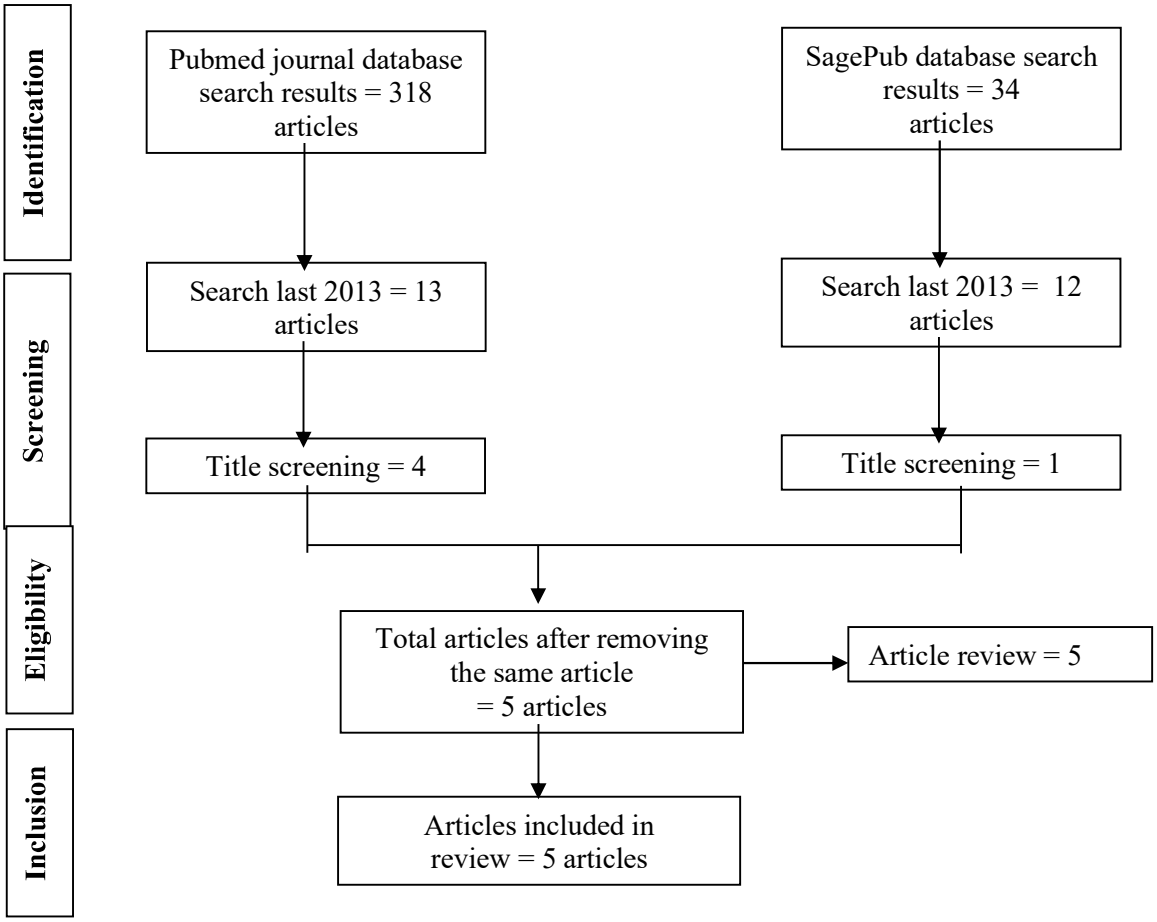

Figure 1. Article search flowchart

Only those papers that were able to satisfy all of the inclusion criteria were taken into consideration for the systematic review. This reduces the number of results to only those that are pertinent to the search. We do not take into consideration the conclusions of any study that does not satisfy our requirements. After this, the findings of the research will be analysed in great detail. The following pieces of information were uncovered as a result of the inquiry that was carried out for the purpose of this study: names, authors, publication dates, location, study activities, and parameters.

Quality Assessment and Data Synthesis

Each author did their own study on the research that was included in the publication's title and abstract before making a decision about which publications to explore further. The next step will be to evaluate all of the articles that are suitable for inclusion in the review because they match the criteria set forth for that purpose in the review. After that, we'll determine which articles to include in the review depending on the findings that we've uncovered. This criteria is utilised in the process of selecting papers for further assessment. in order to simplify the process as much as feasible when selecting papers to evaluate. Which earlier investigations were carried out, and what elements of those studies made it appropriate to include them in the review, are being discussed here.

RESULT

In the PubMed database, the results of our search brought up 318 articles, whereas the results of our search on SagePub brought up 34 articles. The results of the search conducted for the last year of 2013 yielded a total 13 articles for PubMed and 12 articles for SagePub. In the end, we compiled a total of 5 papers, 4 of which came from PubMed and 1 of which came from SagePub. We included five research that met the criteria.

Klaman, et al[8] (2013) showed that both precedures the trabecular aspiration and ab interno trabeculectomy ave the ability to significantly lower the postoperative IOP during the first year. However, clear cornea phacoemulsification combined with Trabectome seems to be more effective in IOP reduction in cases of PEX glaucoma associated with cataract.

Fea, et al[9] (2014) showed that the use of iStent *inject* is at least as effective as two medications, with the clinical benefit of reducing medication burden and assuring continuous treatment with full compliance to implant therapy as well as having a highly favorable safety profile.

Katz, et al[10] (2015) showed that implantation of each additional stent resulted in significantly greater IOP reduction with reduced medication use. Titratability of stents as a sole procedure was shown to be effective and safe, with sustained effect through 18 months postoperatively in OAG not controlled with medication.

Table 1. The litelature include in this study

Author	Origin	Method	Sample	Result
Klamann et al, 2013	German	Retrospective Comparative Cohort Study	27 patients	Examinations were performed prior to surgery, 1 day, 6 weeks, 3 months, 6 months, and 1 year after surgery. In both groups there was a statistically significant decrease in postoperative IOP during the whole follow-up period. Comparing the two groups, there was a statistically significant lower IOP in the Trabectome group 1 day ($p = 0.019$), 6 months ($p = 0.025$), and 1 year ($p = 0.019$) after surgery. Between the two groups, there was no statistically significant difference in the number of antiglaucoma eyedrops at any time.
Fea et al, 2014	Italy	Retrospective Study	94	At the month 12 visit, 94.7% of eyes (89/94) in the stent group reported an unmedicated intraocular pressure (IOP) reduction of ≥20% versus baseline unmedicated IOP, and 91.8% of eyes (88/98) in the medical therapy group reported an IOP reduction ≥20% versus baseline unmedicated IOP. A 17.5% between-group treatment difference in favor of the

				iStent *inject* group was statistically significant (P=0.02) at the ≥50% level of IOP reduction. An IOP ≤18 mmHg was reported in 92.6% of eyes (87/94) in the iStent *inject* group and 89.8% of eyes (88/98) in the medical therapy group. Mean (standard deviation) IOP decreases from screening of 8.1 (2.6) mmHg and 7.3 (2.2) mmHg were reported in the iStent *inject* and medical therapy groups, respectively.
Katz et al, 2015	USA	Retrospective study	41 patients	A total of 38 subjects were implanted with one stent, 41 subjects with two stents, and 40 subjects with three stents. Furthermore, 64.9%, 85.4%, and 92.1% of the three respective groups achieved unmedicated IOP ≤15 mmHg. Over the 18-month follow-up period, medication was required in seven one-stent subjects, four two-stent subjects, and three three-stent subjects. Month 18 IOP reduction was significantly greater (P<0.001) with implantation of each additional stent, with mean differences in reduction of 1.84 mmHg (95% confidence interval 0.96–2.73) for three-stent vs two-stent groups and 1.73 mmHg (95% confidence interval 0.83–2.64) for two-stent vs one-stent groups.
Fea et al, 2015	Italy	Retrospective Study	36 patients	At the long-term follow-up visit we reported a mean IOP of 15,9 ± 2,3 mmHg in the iStent group and 17 ± 2,5 mmHg in the control group (p = NS). After washout, a 14,2% between group difference in favour of the combined group was statistically significant (p = 0,02) for mean IOP reduction. A significant reduction in the mean number of medications was observed in both groups compared to baseline values (p = 0,005 in the combined group and p = 0,01 in the control group).
Kurji et al, 2017	Canada	Retrospective Study	55 patients	Thirty-six eyes of 30 patients had PT and 34 eyes of 25 patients had Pi. Baseline IOP was higher in the PT group

				(20.92 ± 5.07 mm Hg) than in the Pi group (17.47 ± 4.87 mm Hg; p = 0.026). At 12 months there was no significant difference between groups in relative reduction of mean IOP (PT -5.09 ± 5.73, 24% relative reduction vs. Pi -3.84 ± 3.80, 22% relative reduction; p = 0.331) or glaucoma medication use (PT -0.49 ± 1.17 vs. Pi -0.26 ± 0.73; p = 0.168) from baseline. However, Pi had significantly fewer individual complications (PT 20 vs. Pi 5; p < 0.0001) throughout the postoperative period.

Fea, et al[11] (2015) showed that patients in the combined group of micro bypass implantation and phacoemulsification maintained low IOP levels after long-term follow-up. Cataract surgery alone showed a loss of efficacy in controlling IOP over time. Both treatments reduced the number of ocular hypotensive medications prescribed.

Kurji, et al[12] (2017) showed that at the 12 months of follow up, both techniques the phacotrabectome and phaco iStent significantly lowered the IOP but feewer complicationts were observed in the phaco iStent group.

DISCUSSION

Glaucoma is a chronic progressive ocular pathology that affects the optic nerve and results in irreversible vision loss. The condition is also called the silent thief of sight, as it slowly damages the optic nerve before any noticeable central vision loss can occur. The damage is due to persistently raised intraocular pressure (IOP), which damages the optic nerve and causes visual field defects. The medical management of glaucoma is by either topical antiglaucoma medications, laser peripheral iridotomy, or laser trabeculoplasty to lower the IOP. The surgical management is in the form of trabeculoplasty or glaucoma drainage devices. The surgical management options are associated with many intraoperative and postoperative complications, require long-term follow-up, and may have prolonged recovery time. The surgical management options are indicated for severe diseases when medical management fails. Over the years, there have been limited options for mild-to-moderate illness patients with uncontrolled IOP. To fill this gap, novel microinvasive or minimally invasive glaucoma surgery (MIGS) has been introduced. Patients with mild-to-moderate glaucoma who are noncompliant or intolerant to topical drugs are ideal cases for MIGS. The MIGS implant can be implanted during phacoemulsification surgery, reducing dependence on topical medications. This activity highlights the indications, contraindications, classification, technique, complications, and clinical significance of performing MIGS by an interprofessional team.[13]

Minimally invasive glaucoma surgery (MIGS) has emerged in the past two decades as a promising approach to address many unmet needs in glaucoma management. MIGS encompasses a broad range of surgical techniques and devices which aim to lower IOP with a more favorable safety profile compared to traditional glaucoma surgeries. These procedures are typically characterized by their ab interno approach, rapid recovery time, and preservation of the conjunctiva for potential future glaucoma surgeries. MIGS has been designed to target different aqueous humor outflow pathways, including Schlemm's canal, the suprachoroidal space, and the subconjunctival space.[14–16]

As the field of MIGS continues to evolve, it is essential to understand the terminology associated with these procedures and devices to facilitate clear communication among researchers, clinicians, and patients. MIGS can be broadly classified based on itstarget anatomical site, approach, and mechanism of action.[17]

The term "ab interno" refers to MIGS procedures that are performed through an internal approach, typically via a clear corneal incision. In contrast, "ab externo" procedures involve an external approach, usually requiring a scleral or conjunctival incision. Ab interno MIGS is generally considered less invasive and have a more favorable safety profile due to their conjunctiva-sparing nature, which reduces the risk of complications such as infection, scarring, and hypotony.[15,18]

MIGS devices can be categorized based on the primary anatomical site they target to enhance aqueous humor outflow and reduce intraocular pressure (IOP). These categories include trabecular meshwork bypass, supraciliary shunts, and subconjunctival filtration devices. Trabecular meshwork bypass devices, such as iStent and Hydrus Microstent, aim to improve the outflow of aqueous humor by bypassing the trabecular meshwork, the primary site of resistance in the conventional outflow pathway. Suprachoroidal shunts, like CyPass Micro-Stent and iStent Supra, target the supraciliary

space, creating an alternative pathway for aqueous humor to exit the eye. Subconjunctival filtration devices, including XEN Gel Stent and PreserFlo MicroShunt, facilitate the creation of a drainage pathway from the anterior chamber to the subconjunctival space, allowing aqueous humor to exit the eye and be absorbed by the conjunctiva and episcleral vasculature.[14]

The benefits and drawbacks of MIGS are often evaluated in comparison to traditional glaucoma surgeries, such as trabeculectomy and glaucoma drainage devices. These advantages and limitations play a crucial role in determining the position of MIGS within the glaucoma treatment paradigm.[14]

Initial management of glaucoma typically involves pharmacotherapy and laser therapy, which are associated with fewer risks compared to traditional glaucoma surgeries. Conventional glaucoma surgeries carry the potential for vision-threatening intraoperative and postoperative complications, including hypotony, infection, suprachoroidal hemorrhage, cataract formation, and the need for additional surgeries. The Primary Tube Versus Trabeculectomy study reported postoperative complications in 29% and 41% of patients in the tube and trabeculectomy groups, respectively, after one year of follow-up. Serious complications that led to the loss of two or more Snellen lines or required repeat surgery occurred in 1% and 7% of patients, respectively. In terms of complication risk, MIGS occupies an intermediate position between pharmacotherapy and laser therapy, which have lower risks, and traditional glaucoma surgeries, which have higher risks.[19]

MIGS offers several advantages compared to traditional glaucoma surgeries, including a better safety profile and faster recovery time. It is generally indicated for the treatment of mild to moderate glaucoma, as the IOP-lowering effect of MIGS is less pronounced than that of traditional glaucoma surgeries. However, the limitations of MIGS should also be considered. These procedures may not achieve the same degree of IOP reduction as traditional surgeries, potentially limiting their efficacy in cases of advanced glaucoma or in patients with a low target IOP.[14–16,18]

Moreover, while MIGS has demonstrated promising results in the short to medium term, long-term outcomes and comparative effectiveness among different MIGS techniques are still under investigation. The cost-effectiveness of MIGS compared to traditional glaucoma surgeries has also yet to be definitively established.[2,20]

In summary, MIGS offers several advantages over traditional glaucoma surgeries, such as an improved safety profile and faster recovery. However, limitations, including potentially inferior IOP-lowering effects and uncertainty regarding long-term outcomes and cost-effectiveness, should be carefully considered when determining the role of MIGS in the glaucoma treatment paradigm. The primary objective of this literature review is to provide an up-to-date, comprehensive summary of the current evidence on MIGS, focusing on their safety, efficacy, and the specific patient populations that may benefit the most from these procedures. We will explore the various MIGS devices and techniques, including trabecular micro-bypass stents, Schlemm's canal scaffolding, suprachoroidal shunts, and subconjunctival filtration devices. Furthermore, we will discuss the advantages and limitations of each MIGS approach, the impact of MIGS on the glaucoma treatment paradigm, and the future directions of research in this rapidly evolving field. Given the rapidly evolving nature of this field and the growing number of approved MIGS devices, it is crucial to regularly assess and synthesize the available evidence to guide clinicians, researchers, and healthcare policymakers in making informed decisions about the use of MIGS in glaucoma treatment.[21]

CONCLUSION

Although MIGS seem efficient in the reduction of the IOP and glaucoma medication and show good safety profile, this evidence is mainly derived from non-comparative studies and further, good quality RCTs are warranted.

Among currently available MIGS for which reliable RCT data have been published, Hydrus was associated with greater drop-free glaucoma control and IOP-lowering than iStent, although effect sizes were small. There are important gaps in the evidence base for MIGS, most notably for subconjunctival devices. Vision researchers and device manufacturers might aid in bridging these gaps with well-designed RCTs reporting effectiveness, safety, and health-related QOL outcomes at 24 months and beyond.

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