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Glaucoma drainage devices: Literature review

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Abstract
One of the leading causes of vision impairment worldwide is glaucoma. Various etiologies for this visual congestion manifest as enlarged intraocular weight (IOP) and optic neuropathy. Nevertheless, the IOP may remain normal in certain situations, such as normotensive glaucoma. Due to its dynamic character, it is essential for an early conclusion even when the degree of vision impairment is mild and cannot be corrected. In complex glaucoma situations where previous trabeculectomy failed, and treatment was not working, glaucoma waste embed operations are becoming a more and more popular option. Plans for glaucoma seepage devices (GDD) vary; they are entwined with understanding the problem and the surgeons' preferences. Following the implantation of a GDD, problems can include the breakdown of the mucosal layer, ejection, plate displacement, hypotony, and endophthalmitis. Different seepage devices are displayed in the showcase; however, some are often used and well-known. A couple of the most widely utilized GDDs and associated difficulties will be looked at in this article. Four stand out: Ahmed, Krupin, Baerveldt, and Molteno. The GDD's rate of dissatisfaction is zero. It has been well-known in several studies that half of the GDD is still relevant after five years. Therefore, efforts to improve the biomaterials, processes, and design of the GDD are ongoing. Additionally, the surgical method is critical to the success of GDD. The kind of glaucoma is a crucial consideration when selecting a course of treatment, as it also influences the outcome of surgery.

Keywords: Glaucoma, GDD, surgery

Introduction
Numerous visual problems can produce glaucoma, a dynamic and persistent neuropathy of the optic nerve that can result in unfortunate eyesight. Elevated intraocular weight (IOP) is the most well-known risk factor that can result in visual misfortune [1]. Ancient age, a family history of glaucoma, and certain racial groups are risk factors for glaucoma [2]. Most of the time, the illness goes undiagnosed in its early stages of infection and is asymptomatic. To avoid irreversible visual impairment, the doctor must screen all high-risk cases. Glaucomatous optic neuropathy (GON) is an optic neuropathy that is ultimately caused by several disorders. Various reports indicate that the optic nerve head is the primary injury site [3].

There are many causes for the increase in intracranial pressure (IOP); the most prevalent ones are as follows: (1) increased IOP arrangement rate, (2) IOP seepage issues, and (3) an increase in the weight of the episcleral vein [4]. The expanding resistance inside the seepage of the watery funniness through the front chamber's point and the circulation of watery amusingness at the understudy are typically the causes of the weight rise. These considerations should be examined when selecting glaucoma inserts because knowing the specific cause is crucial for treating chronic cases, particularly when inserting them [5].

The two primary diseases associated with glaucoma are (1) mechanical alterations brought on by an increased intraocular pressure and (2) decreased perfusion of the optic nerve head [6]. While damage cannot be undone, it can be prevented by setting the trash electronics aside.

Typically, glaucoma is classified as either essential or auxiliary. It is recommended to distinguish between open-angle and angle-closure glaucoma when dealing with significant adult glaucoma. Auxiliary glaucoma can result from any eye condition. Treatment options for primary open-angle glaucoma include the use of beta-blockers and prostaglandin. Laser trabeculoplasty is a fantastic backup plan if this treatment cannot address the underlying reason. Significant angle-closure glaucoma is under Nd's control: YAG iridotomy in both eyes. After that, the understanding must have their IOP evaluated at regular intervals for the remainder of their lives. Treatment for auxiliary open-angle glaucoma can be monitored, but if it is unable to control the symptoms, surgery is the next best option. A goniotomy or trabeculectomy can manage intrinsic glaucoma, while treatment for auxiliary angle-closure glaucoma focuses on reducing irritation and intraocular pressure [7].

Glaucoma can be treated with a laser, surgery, or solutions (topical or systemic IOP-reducing agents). Many glaucoma drugs have been introduced to the market in recent years, and the use of trabeculoplasty (laser) surgery has increased in place of invasive incisional surgery [8]. The devices known as GDDs are utilized to drain water from the anterior chamber into the store, which is formed remotely weeks following surgery to maintain the stream. These devices are successful regarding corneal scarring from unsuccessful trabeculectomy attempts or previous vision procedures [9]. Glaucoma can be managed with medications, laser procedures, and trabeculectomy.

These days, glaucoma drainage implants are also excellent options. It has been well-known for many years that these devices successfully regulate intraocular pressure in patients whose previous attempts at trabeculectomy failed. In the exhibition, many devices have been developed in response to surgical necessity. Essential factors in selecting the embed include the surgeon's inclination, the optic nerve state, and the preoperative IOP [10].

Using silk string to deplete glaucoma was Zorab's primary method of glaucoma waste [11].

The GDD is categorized by (1) type of fabric: Materials like silicon and polypropylene are used to make the glaucoma waste devices; examples of silicone inserts are Baerveldt, Krupin, and Ahmed, while examples of polypropylene inserts are Ahmed and Molteno (2) kind of opening: There are two types of glaucoma waste devices: valvular and non-valvular. Ahmed and Krupin are the valvular implants [12]. Molteno and Baerveldt are non-valvular implants.

Method

The study method is Systematic Review. Destination in the study to find out various models of glaucoma drainage devices. Method search use Prism chart 2020, search literature for authenticity research this conducted with literature review use keywords "Glaucoma Drainage Device" until year 2024. Search results 1,026 articles were found however only 39 articles match with criteria research. Article found from Scopus, Science Direct, ProQuest, PubMed, Google scholar.

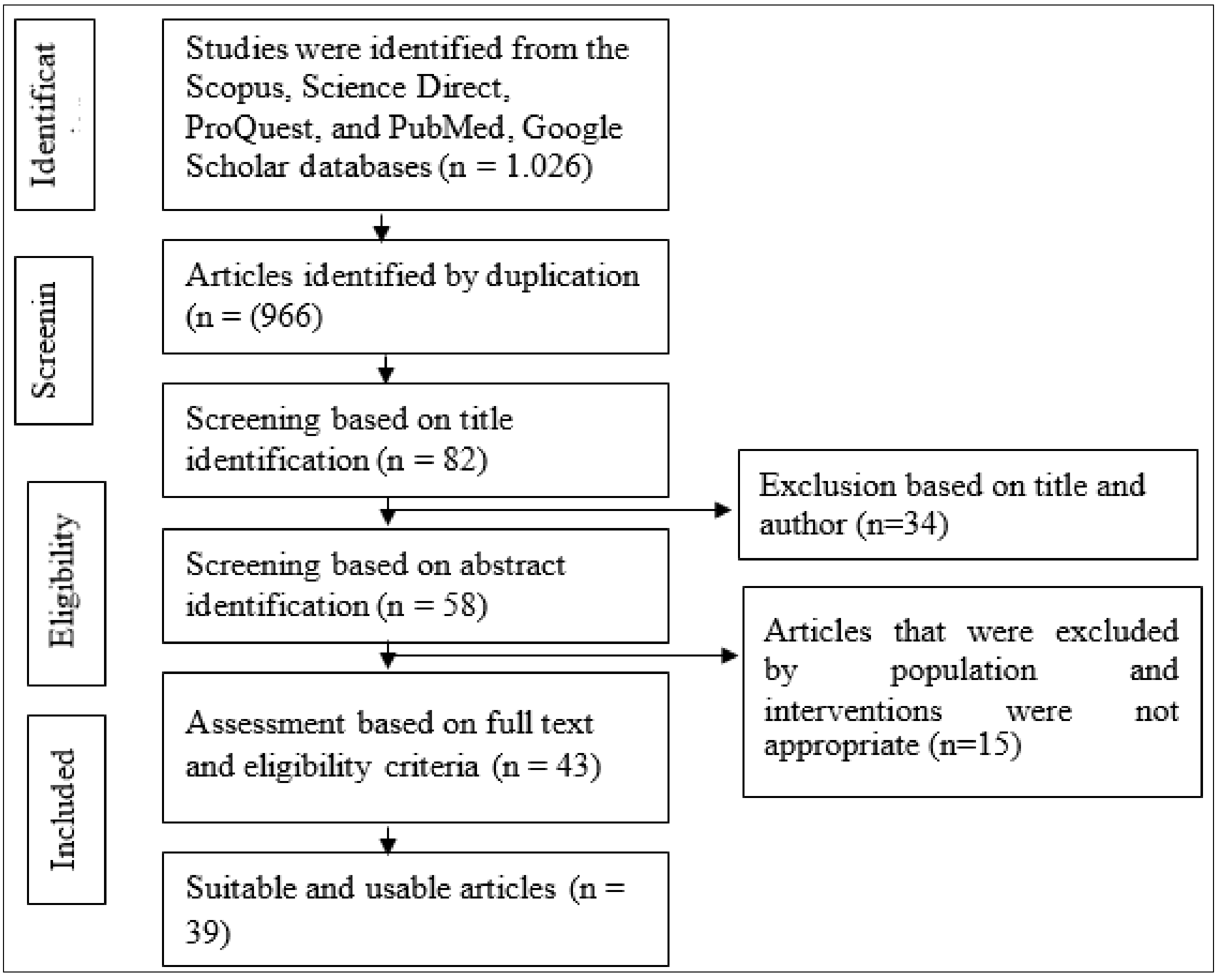

Fig 1: Literature Search Using Prisma 2020 with Glaucoma Drainage Device Scope (Systematic Review)

Review

Distinctive inserts are created occasionally after watching the complications of the already-displayed gadget. As unique inserts are designed, alterations are made, concurring with the complications of the past one.

Table 1: The Advancement of diverse inserts

Methods	Summary
Molteno	The Molteno implant device is a non-valvular gadget used to manage refractory glaucoma. The device is composed of a tube made of silicon and connected to a tube placed 9-10mm back to the limbus inside subconjunctival space. The plate of the Molteno implant is sutured to the sclera, and a bleb is shaped over it to absorb aqueous. Over the years, the Molteno implant device has been modified to a double-plate model, which has been found to provide better drainage of the aqueous than the single-plate model. However, the device has its complications, but modifications in surgical techniques and design have reduced some of them. Overall, the Molteno implant is a good option for managing refractory glaucoma.
Baerveldt	In 1990, a non-valvular implant was presented for the surgical treatment of obstinate glaucoma. The Baerveldt glaucoma drainage device (BGDD) is superior to previous implants due to its larger surface area and easier implantation process. The implant is non-valvular and made of impregnated barium and modified silicon. It has been effective in reducing intraocular pressure and treating glaucoma with uveitis. However, its rate of survival decreases over time, often requiring multiple surgeries. Complications include corneal edema, tube obstructions, motility disorders, diplopia, hyphema, and rare cases of phlebitis and retinal separation. Postoperative complications can be reduced with careful planning and consideration of the surgical procedure.
Aurolab Aqueous Drainage Implant (AADI)	The AADI embed has a surface zone of 350 mm^2 with horizontal wings positioned beneath the rectus muscle. It is a non-valvular GDD based on BGDD and is cost-effective for pediatric glaucoma in developing countries. The embed's large surface area leads to low IOP without the risk of bleb embodiment. There may be an increased IOP during the first few weeks, but medication can control it. The embed has been available in India since 2013.
Krupin	In 1974, the Krupin embed was created, consisting of an open Silastic tube with a length of 20mm and an exterior breadth of 0.58mm and interior breadth of 0.38mm. The tube has vertical and flat openings at the distal end and a unidirectional pressure-sensitive valve. The calibration criteria for manometry are 10-12 mmHg for opening and 8-10 mmHg for closing weights. The gadget's episcleral portion is an oval Silastic circle, 13*18 mm, with a 1.75 mm side divider, which fixes the globe's ebb and flow.
African Ahmed Glaucoma Valve	The African Ahmed glaucoma valve (AAGV) is a device used to control intraocular pressure (IOP) in secondary glaucoma. It consists of a plate, drainage tube, and valve made of silicone or polypropylene materials. The AGV comes in adult and pediatric versions, with flexible or rigid plates. The M4 is a new version with a porous high-density polyethylene case that reduces complications. While the AGV is effective in controlling IOP, it can cause hypotony post-surgery and other complications such as exposure to the tube. Precautions should be taken during surgery to prevent these issues. Strabismus and diplopia are common post-surgical complications.

Molteno

It offers the central idea upon which all of the show date's GDDs are predicated [13]. Over time, some modifications were made to its unique strategy, and advancements in the surgery have produced significant successes and decreased rates of complications. The Molteno implant is a non-valvular device consisting of a silicon tube connected to a tube positioned in the subconjunctival area 9–10 mm posterior to the limbus. The Molteno embed plate is sutured to the sclera. A fibrovascular and porous bleb is then formed over the plate, held by connected tissue and conjunctiva. Its surface area adds to the total fluid waste and final IOP [13]. When examined in detail, this embed comprises a lean tube that opens onto a circular acrylic plate, 13 mm in diameter, has an exterior breadth of 0.6 mm, and an inward distance of 0.3 m. The plate's 0.7 mm thick edge is too perforated to be connected to the sclera by sutures, preventing the plate from disengaging [14]. The Molteno embed was the primary device that was used to reduce glaucoma. First of all, this GDD was administered in 1969.

A double plate version of the Molteno implant device was updated recently, which helps expand the possible area for water absorption. The two 13 mm-diameter plates in this dual plate variant are joined by a 10 mm-diameter tube. The double-plate approach requires more excellent expertise and technique than the single-plate form. The surface area available for water absorption is doubled in this model. Additionally, it has been discovered that the two-plate model, as opposed to the plate or four-plate model, offers superior aqueous drainage [14].

For refractory glaucoma, the Molteno implant device is frequently utilized. It is not without difficulties, though; some are lessened but not eliminated by changes in surgical procedures, such as temporarily ligating the tube during tube insertion, changing the needle track utilized, and using a donor scleral patch. There have been reports of postoperative hyphema in certain neovascular glaucoma patients. However, this ailment doesn't impact the outcome of the surgery and usually goes away a few days after it manifests. Aqueous leaking surrounding the silicon tube is the cause of hypotony and shallow anterior chamber in certain circumstances. Though they only occur rarely, several other serious side effects, such as vitreous hemorrhage and retinal detachment, have also been documented [15]. The Molteno implant becomes a viable alternative for treating refractory glaucoma because it facilitates the drainage of aqueous humor from the anterior chamber to the posterior reservoir. Adjustments lessen the issues related to surgical technique and design changes for the Molteno implant.

Baerveldt embed

This embed was first presented for the surgical treatment of obstructive glaucoma in 1990. Since this embed only has one plate and no valve to control the stream, it is essential to ligate the tube during surgery to create enough room for liquid assimilation [16]. Specifically, the Baerveldt glaucoma seepage device (BGDD) is superior to previous inserts in two aspects: firstly, the implantation handle is relatively simple, and secondly, the surface zone is large (the reason the surface range is superior is because fluid funniness is distributed by the bleb divider including the embed, and IOP reduction is proportionate to the bleb range). The BGDD's longer, lower control on weight is demonstrated by its larger surface area compared to a single small plate Molteno device [17].

Between the two rectus muscles, BGDD is typically positioned as either horizontal and predominant or second rate or average; this necessitates, in a sense, the fragmentation of the conjunctiva on one quadrant [17]. The moo IOP may be sustained for an extended period via the non-valvular BGDD tube by helping to maintain moo resistance to the stream [17]. This non-valvular embed is made of silicon that has been modified and impregnated with barium, with a surface area ranging from 250 to 350 mm^2 [18]. Similar to the Molteno embed, this embed has several highlights. However, it differs because it uses fragile silicon [19]. In patients with uncontrollably high intraocular weight glaucoma, BGDD was effective in reducing intraocular weight [20]. Additionally, this insert is safe and effective in treating uveitis-related glaucoma. [21]. A few times can be permitted for the BGDD inferonasal implant, which proved to be a viable and secure procedure [22]. This embed initially has a very high success rate, but it shows a declining survival rate with time.

This typically calls for several procedures to maintain IOP and preserve vision [23]. Headstrong glaucoma patients with tall intraocular weight can benefit from BGDD treatment. When managing glaucoma presents challenges, such as neovascularization of the iris or conjunctival scarring, the operation should be carefully planned, and careful planning can reduce the risk of complications after the surgery.

By the concerns, corneal edema frequency is most notable in postoperative instances, and tube complications - including obstruction, disintegration, and malposition - are the other most frequent problems. Other potential consequences following surgery are motility clutter (2-17%), diplopia, and hyphema (2-19%) [24]. There are far less severe postoperative problems, such as phlebitis (1-2%) and retinal detachment (1-2%). After surgery, no discernible light was discovered in only 6% of the patients [25].

Aurolab watery waste embed (AADI)

The AADI has a 350 mm^2 surface area shaped like a butterfly with horizontal wings beneath the rectus muscle. Obsession gaps are demonstrated to help the final plate remain 10 mm apart from the limbus [26]. Its structure is based on BGDD and might be a non-valvular GDD. The main advantage of this embed is that it is far more affordable than the Ahmed embed, which makes it especially helpful in developing countries where childhood glaucoma is common [27]. Since 2013, it has been available for purchase in the Indian market.

Compared to devices with valves, this insert offers a large surface area, which affects the moo IOP. Since the bleb isn't explicitly exposed to the judges of aggravation from the anterior chamber, the likelihood of it materializing is much lower. This is especially true if the tube is opened, which is expected to occur after four to six weeks [28]. Thus, there is no such hypertensive period as with valvular devices; nonetheless, there may be scenarios of increased IOP in the early weeks until the ligatures give way. To control the IOP, the persistence should be on solutions from the outset [29].

Krupin

In 1974, the Krupin embed concept was developed. This embed is an open Silastic tube with an outer width of 0.58mm and an interior width of 0.38 mm. This tube is 20 mm long, although it can be shortened when positioned inside the front chamber during surgery. The vertical and flat apertures are visible at the distal end of the Silastic tube, which can function as a unidirectional, pressure-sensitive valve [30]. The opening and closing weights serve as the criteria for calibrating manometry. The last mentioned is 8–10 mmHg, and the preceding is 10–12 mmHg. The device's part, measuring 13 by 18 mm and including a 1.75 mm side divider, is an oval Silastic circle within the episcleral portion. The ebb and flow of the globe is fixed by the shape of the circle [31].

Ahmed glaucoma valve

Mateen Ahmed proposed it, and the US Nourishment and Medicate Organization affirmed it in 1993 [32]. It is made of three parts:

1. Plate, which can be made up of polypropylene, silicone. or polyethylene (permeable).
2. Seepage tube made of silicone.
3. Valve, which is also made of silicone [32].

The Ahmed glaucoma valve (AAGV) comes in two shapes

1. Adult (S2), which incorporates a surface range of 180 mm^2, and
2. Pediatric (S3) contains a surface region of 96 mm^2.

This embed is displayed in two adaptations: one is unbending, and the other is adaptable. The inflexible is made up of polymethylmethacrylate, and the adaptable one is made up of silicone elastic. Both are shown in either one or two-plate models. These, moreover, contain valves that limit the stream, which makes a difference in anticipating hypotony postoperatively. It has been detailed that AAGV, made up of silicon, is more viable in controlling the IOP But is too related to more chance of complications than the polymethylmethacrylate one [16].

As of late, an unused demonstration of AAGV. Has been presented: M4, which could be an adjustment of AAGV S2, which contains an indistinguishable valve component, but the case is made up of porous high-density polyethylene. The full range of the plate is 160 mm^2, from which the surface range of pores is avoided. The pores resist illness and facilitate the formation of fibrotic and vascular tissues [32]. AAGV might be an excellent substitute for auxiliary glaucoma. A few surgical techniques should be taught to the specialist sometime after the surgery, even though it is a client-inviting process. AAGV embed is superior to non-valvular devices for the straightforward postoperative management of glaucoma. However, hypotonia in the initial postoperative phase may still pose a risk [33].

The purpose of the AAGV is to reduce hypotony following surgery, allowing fluid to leak when intraocular weight is between 8 and 12 mmHg. Compared to non-valvular inserts, some believe these components significantly reduce postsurgical hypotony, but they cannot wholly eradicate it [34]. When there is still no evidence of an AAGV embed, diligent hypotony occurs. Nonetheless, certain precautions should be followed during the procedure, like avoiding overpriming the tube and not overregulating the valve lodging [35]. Presentation to the tube is the most frequent complication of all glaucoma drainage implants. For AAGV, this is frequently caused by the conjunctiva and the patch that covers it disintegrating. It has been shown that in the late postsurgical period, it occurs in only 2–7% of instances [24]. The most frequent postoperative consequences of all glaucoma implant devices are diplopia and strabismus [32].

Discussion

Based on the search results, there are several studies and articles that compare different types of glaucoma drainage devices (GDDs). One study [36] compared the outcomes of sulcus placement of GDDs versus traditional anterior chamber (AC) placement and found that sulcus placement resulted in fewer complications, including lower rates of hyphema and severe or late complications. Another study [37] compared the surgical outcomes of Ahmed glaucoma valve (AGV) and Aurolab aqueous drainage implant (AADI) in Nepalese eyes and found that both devices were effective in reducing intraocular pressure (IOP) and the requirement for antiglaucoma medications (AGMs), but AADI had significantly lower IOP and AGM requirements compared to AGV. A third article [38] studied the possibility of performing modified Descemet membrane endothelial keratoplasty (DMEK) with maximum graft diameter in the presence of a GDD in the anterior chamber and found that it was technically possible and effective in treating bullous keratopathy. Finally, a study [39] described the development and validation of a test facility for pivotal characterization of GDDs, which could potentially enable pressure-flow characterization of test specimens in a wide flow range. Overall, these studies suggest that different types of GDDs have varying outcomes and effectiveness in reducing IOP and complications, and further research is needed to determine the optimal device for individual patients. Both Ahmed glaucoma valve (AGV) and Aurolab aqueous drainage implant (AADI) were effective in reducing intraocular pressure (IOP) and the requirement for antiglaucoma medications (AGMs). AADI had significantly lower IOP and AGM requirements compared to AGV. *Disadvantages*: The study did not explicitly mention any specific disadvantages of either AGV or AADI. In general, the advantages of GDDs include effectively reducing IOP and the requirement for AGMs. However, the choice of GDD may depend on various factors such as the patient's specific condition, the risk of complications, and the surgeon's expertise. Further research and clinical trials may provide more comprehensive insights into the advantages and disadvantages of different GDDs.

Conclusions

Glaucoma drainage devices are a practical alternative when the trabeculectomy does not work. A few factors, such as the surgeon's preference, the patient's IOP before surgery, and the condition of the optic nerve before surgery, should be considered when selecting an implant because there are now many models available in the market in various shapes and sizes. The size of the bleb also influences the choice of an implant since the bleb's area directly correlates with the amount of aqueous humor that diffuses from its wall. According to the new changes that have been made and are detailed in the article, several previous procedures have demonstrated a variety of difficulties. Although the development of drainage devices is a significant advancement in medical science, the physician must manage some drawbacks. However, there are still had many complications that need to be observed by the doctor. The article aims to educate readers, including professionals and laypeople, about the benefits and disadvantages of the various implant kinds.

Conflict of Interest

Not available

Financial Support

Not available

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