Glaucoma Drainage Device

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การรักษาโรคต้อหิน ในรายที่ไม่สามารถควบคุมระดับความดันในลูกตาได้ด้วยยา เลเซอร์ หรือการผ่าตัดด้วยวิธี trabeculectomy นั้น ปัจจุบันเทคนิคที่ดีที่สุดคือการใช้ Glaucoma drainage device ซึ่งมีหลายชนิด จักษุแพทย์จึงควรรู้จัก Glaucoma drainage device แต่ละชนิด เพื่อนำไปประกอบการตัดสินใจให้การรักษาผู้ป่วย

Glaucoma drainage implants reduce the IOP of the eye by directing the outflow of the aqueous humor through a shunt device. The shunt device channels the aqueous humor in an alternate pathway through a small tube into an outlet chamber.

The four main implants currently in use are the Ahmed glaucoma valve, the Baerveldt glaucoma implant, the Krupin slit valve, and the Molteno implant. These devices contain two main components, a long tube to shunt the aqueous, and an outflow device. The implants differ in their surface area, materials, and flow resistance. Polypropylene, used in Ahmed and Molteno implants, appears to cause more inflammation than silicone that is used in Baerveldt and Krupin implants.

The Intra Ocular Pressure (IOP) of the patient is lowered by providing the aqueous humor with a new outflow pathway through the implant. The amount of outflow is dependent on the resistance encountered at the end of the plate. This resistance is dependent on the surface area of the implant encapsulation and the capsular thickness. Implants with a larger surface area and a thin capsule at the end of the plate will have a greater effect in lowering the patient's IOP.

The Ideal Drainage Device

- Easy to implant
- Consistently reduced IOP
- Avoided complications
- Inert biomaterials
- Effective over patient's lifetime

Valved Implants

Valved implants contain an internal mechanism to control the outflow of the aqueous humor. These devices are designed so fluid is not able to drain through the shunt unless a minimum IOP is reached. The valved devices prevent hypotony.

Non - Valved Implants

Non - valved implants do not contain a mechanism within the device to restrict the aqueous outflow. The non - valved implants rely on a fibrous bleb that is formed on the end plate. The size of the end plate surface area and the thickness of the fibrous bleb determine the amount of resistance in the device.

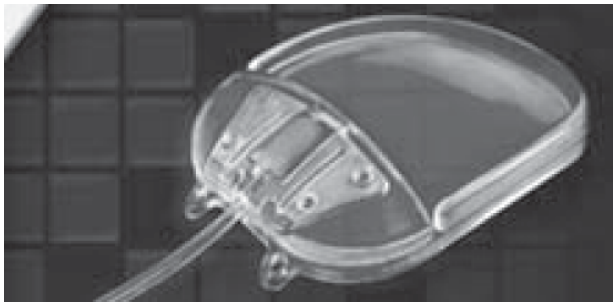
Table 1 Glaucoma Drainage Device

	Molteno		Baerveldt		Krupin	Ahmed	
	Single plate	Double plate	250	350		Single plate	Double plate
Surface area	135 mm^2	270 mm^2	250 mm^2	350 mm^2	194 mm^2	184 mm^2	364 mm^2
Height profile	2.16 mm	2.16 mm	0.84 mm	0.84 mm	2.54 mm	1.90 mm	1.90 mm
Plate material	Polypropylene	Polypropylene	Silicone	Silicone	Silicone	Polypropylene or Silicone	
Tube	Open	Open	Open	Open	Valve	Valve	Valve

Valves Implants

Ahmed Glaucoma Valve (AGV)

Figure 1 Ahmed Glaucoma valve[3]



Characteristics and Purpose

The AGV consists of a plate and a unidirectional valve system controlling eye pressure by draining excess fluid out of the eye through a tube connected to the plate.

Components, materials and models of AGV:

The Ahmed Glaucoma Valves consist of:

- Plate(s) in silicone or medical grade polypropylene (radiation resistant)
- A drainage tube in medical grade silicone
- A valve in medical grade silicone (elastomer membrane)

Two AGV models come with a polypropylene plate:

- Ahmed Glaucoma Valve (S2) (conventional AGV)
- AGV Bi-Plate (B1)

Two similar models exist in silicone:

- AGV Flexible Plate (FP7)
- AGV Flexible Bi-Plate (FX1)

Both single-plated models (S2 and FP7) exist in pediatric sizes, to allow better adhesion to children's eyeballs.

According to a study conducted at the Jules Stein Eye Institute, UCLA School of Medicine

(Comparison of safety and efficacy between silicone and polypropylene Ahmed glaucoma valves in refractory glaucoma), there is no significant difference in clinical outcomes with the silicone and polypropylene AGVs.

Mechanics and flow through the valve

When the intraocular pressure is too high (8-12 mmHg), the valve opens, thus letting fluid flow out of the eye through the drainage tube. The valve automatically closes when the pressure is normal again.

Aqueous humor from the anterior chamber of the eye flows (thick black arrow on the picture) through the tube into the trapezoidal chamber within the plate element. This chamber is formed by a folded-over silicone elastomer membrane with its free edges forming a one way valve and producing a Venturi effect.

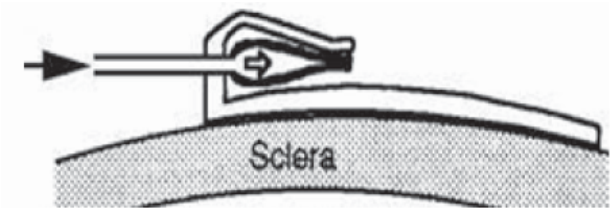
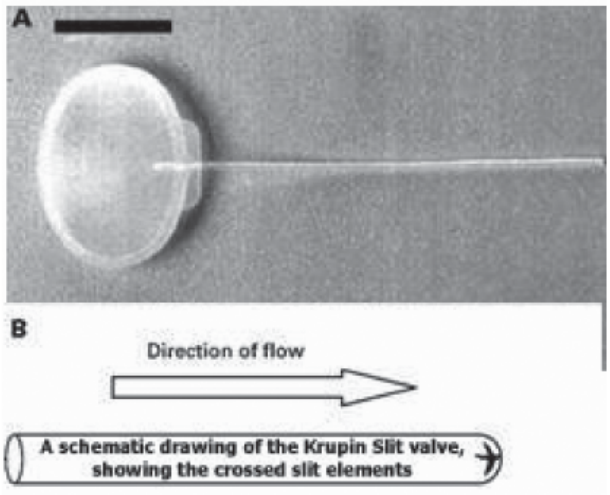


Figure 2 Schematic drawing of the resistance mechanism of the Ahmed Glaucoma Valve

Krupin Eye Disk

The Krupin slit valve, consists of a silastic tube with a lumen diameter of 0.38 mm, attached to a 1.75 mm thick, oval, silicone plate with a surface area of 180 mm2. The tube incorporates a one-way valve, which is intended to maintain an IOP of a least 9 mmHg to 11 mmHg. The tube's distal end is sealed and there are several horizontal and vertical slits. As IOP increases, the tube elastically deforms and permits fluid to enter the explants.

Figure 3 Schemetic drawing of the Krupin Slit valve[4]



Non - valve Implants

Molteno Glaucoma Implants

The Molteno® implant, was the first aqueous shunt to gain widespread acceptance, with the initial model being released in 1976. The plate initiates the formation of a large circular bleb, which develops a specialized fibrovascular bleb lining. The lining is responsible for regulating the flow of the aqueous humor from the eye, and thus determines the intraocular pressure of the eye.

The single plate implant has a 13 mm diameter, a maximum plate thickness of 1.65 mm with a surface area of 135 mm^2, while the double-plate design increases the surface area of the bleb

to 270 mm^2, by attaching a second plate to the main plate via a 0.34 mm internal diameter tube. Both single and double plate model exist with a subsidiary pressure ridge on the upper surface of plate(s) in order to reduce hypotony in the immediate postoperative period when covered by Tenon's tissue.

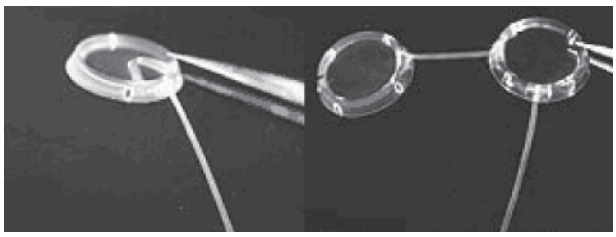


Figure 4 Molteno Glaucoma Implants(4) single plate (left) and double plate (right)

The top surface of the plate is divided into one smaller and one larger chamber by the apposition of the overlying conjunctival and Tenon's layers (dotted line). Aqueous flows (black arrow) into the smaller proximal chamber until sufficient pressure is achieved within the chamber to lift (white arrow) the overlying conjunctival layer to allow free drainage.

Figure 5 Schematic drawing of the resistance mechanism of a dual chamber single plate Molteno implant[4].

Baerveldt

Three models of Baerveldt glaucoma implants, are currently available, BG-103-250, BG-101-350, and BG-101-250 Par Plana. All three implants have been designed with a large plate surface area (250 mm^2, 350 mm^2, 350 mm^2 respectively) in order to maximize aqueous filtration and pressure relief. Current research suggests that large surface areas are more effective in controlling long-term intraocular pressure than comparable implants with smaller surface areas.

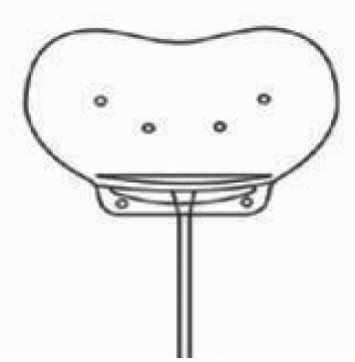


Figure 6 Baerveldt[4]

All three models consist of a silicone tube with a lumen diameter of 0.3 mm attached to 1 mm thick silicone plate impregnated with barium.

The Baerveldt implants also allow for single quadrant insertion, and incorporate four fenestrations in order to encourage tissue in growth. Fibrous tissue in growth both secures the plate in place and decreases the potential for ocular motility disturbances by minimizing bleb volume and height.

Following implantation, the angular ridge on the bottom of the plate provides a temporary seal against the sclera. However, as the absorbable sutures degrade, the plat lifts clear to allow for free aqueous drainage.

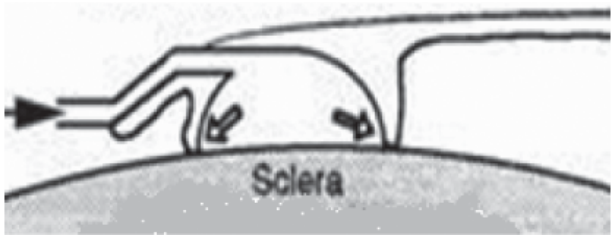


Figure 7 Schematic of appositional resistance mechanism of Baerveldt GDDs(4)

Indications

1. Failed trabeclectomy with antifibrotics
2. Uveitic glaucoma
3. Neovascular glaucoma
4. Severe conjunctival scarring
5. Aphakia or pseudophakia
6. Refractory pediatric glaucoma

Table 2 Success rates of Drainage Implants with Glaucoma

	Drainage implant			
Glaucoma	**Ahmed**	**Baerveldt**	**Molteno**	**Krupin**
Neovascular	68%	78%	67%	77%
Uveitis	100%	92%	83%	N/A
Aphakia, pseudophakia	88%	75%	83%	N/A
Overall success rate	85%	82%	78%	77%

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