A Novel Squid Glaucoma microShunt for Controlled Release of Aqueous Humor

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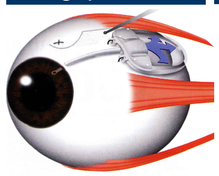
Background

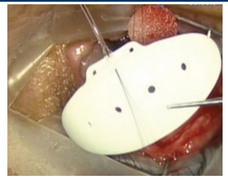
Glaucoma is the second leading cause of blindness, affecting 80 million patients globally and 3 million in the US. Elevated intraocular pressure (IOP), caused by blockage of aqueous humor (AH) outflow from the anterior chamber, is an important risk factor. After medical treatments fail to control IOP, a glaucoma drainage device (GDD) is implanted. Current GDDs have major drawbacks: (1) large sizes requiring extensive surgical dissection, (2) uncontrolled AH release risking vision loss, and (3) prolonged inflammation/fibrosis leading to 50% failure rate at 5 years. To address this clinical need, we designed a new GDD, the Squid Glaucoma microShunt (SGS).

Large plate sizes



High risk of post-surgical fibrosis

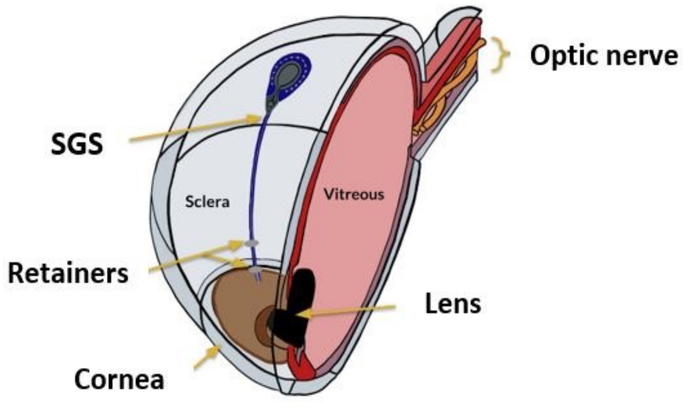
Extensive tissue dissection



Methods

A 3D model of the SGS was rendered using computer-aided-design software SolidWorks. SGS is 90% smaller, designed to release AH in a slow, sprinkle-like fashion. To reduce inflammation, SGS will be coated with patented low-cost ultrananocrystalline diamond (UNCD) film exhibiting superb biocompatibility.

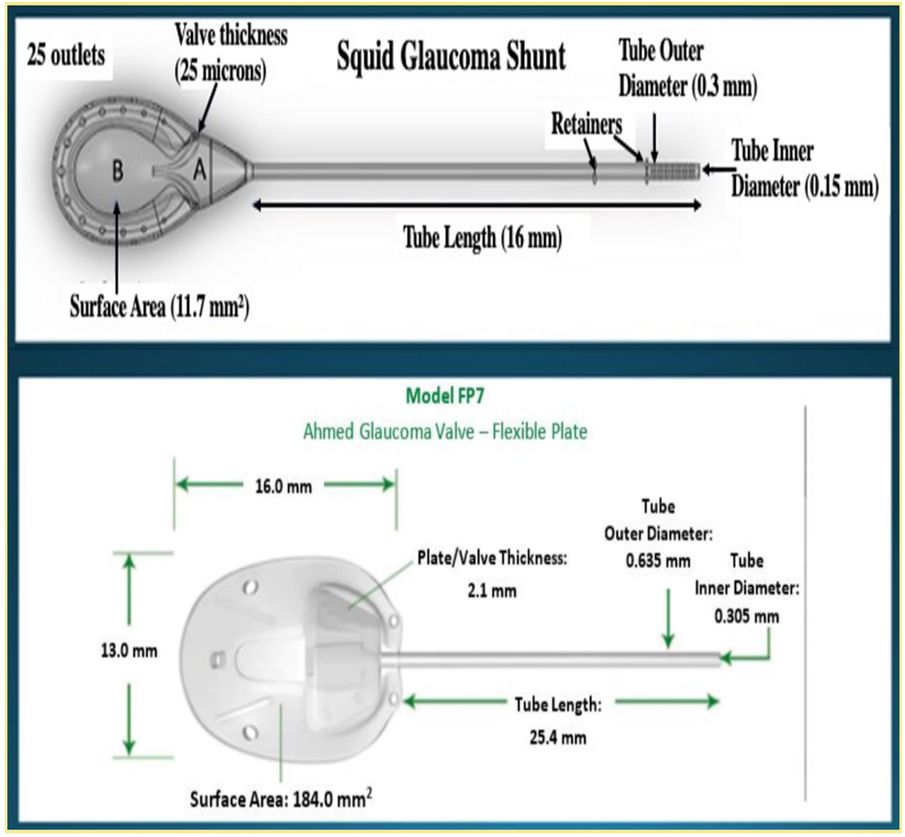
A pair of patented micro forceps were designed for easy insertion, promoting 50% reduction in surgery time. An *in-silico* ANSYS fluidic simulation was designed to study fluid flow and pressure drop. To test the efficacy, UNCD was coated on an Ahmed® Shunt and inserted in a rabbit eye with the control eye having an uncoated shunt.



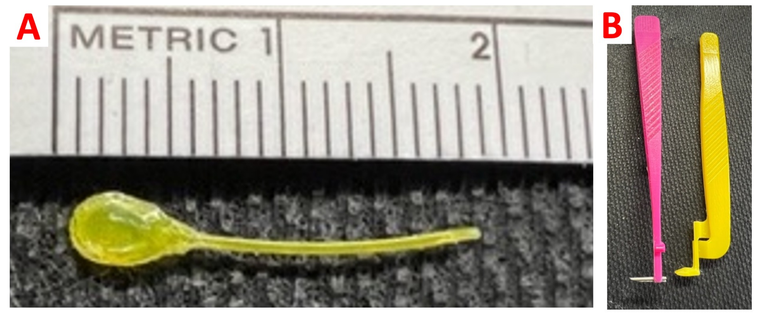
Schematic of SGS on the eye

Results

SGS Design

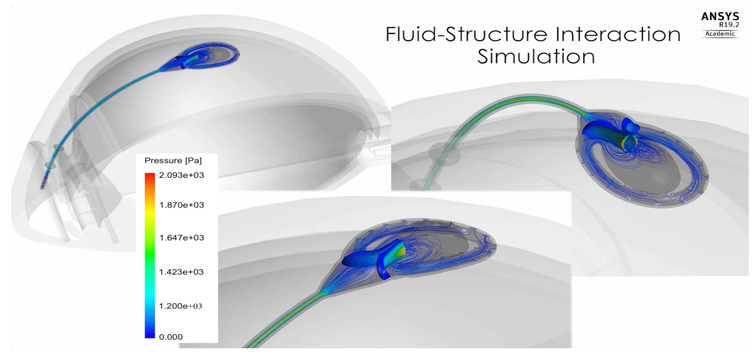


3D Printed Prototypes (SGS & Micro forceps)



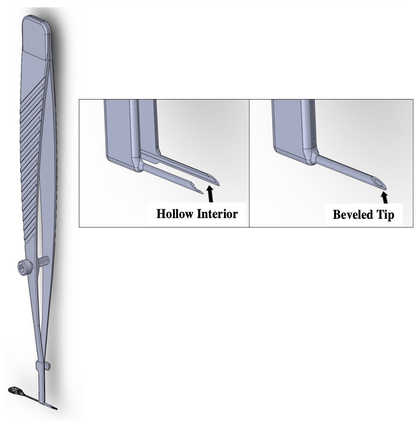
A) SGS, B) Micro forceps Prototypes

In-silico ANSYS Simulation

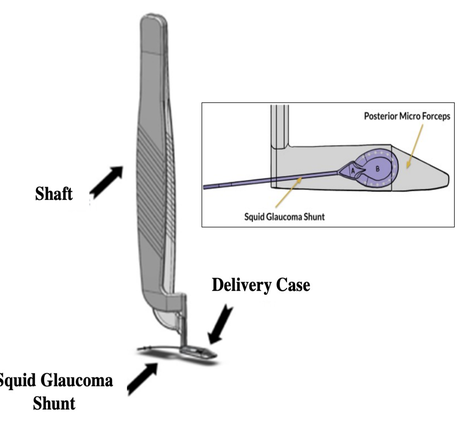


The *in-silico* ANSYS fluidic simulation showed that the SGS reduced IOP by 50% from 17 mmHg to 9 mmHg.

Anterior Micro forceps

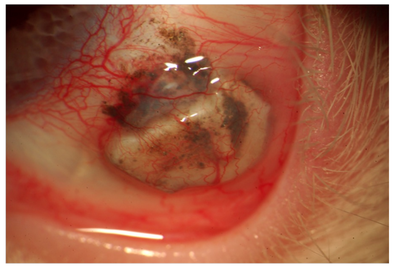


Posterior Micro forceps

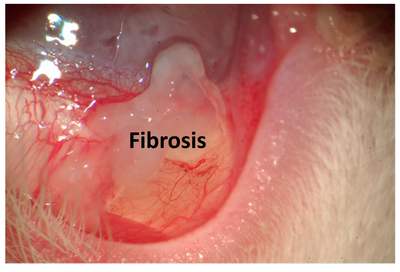


Efficacy of UNCD Coating on Glaucoma Shunt

Shunt with UNCD



Shunt without UNCD



At one year, the rabbit eye with a UNCD coated Ahmed® shunt was quiet with low IOP, while the uncoated eye shunt had failed within days because of intense inflammation and scarring.

Conclusion

Due to the complications associated with current GDDs, only 40% of glaucoma patients undergo surgical interventions. Our minimally invasive SGS implant would make early surgical intervention an option for glaucoma patients with presumably better outcomes and prevent blindness.

References

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