



## Blockage of Schlemm's Canal Orifice after Ab-Interno Canaloplasty Surgery for Glaucoma

Xiaojie Wang<sup>1</sup>, Yanqian Xie<sup>1</sup>, Cong Ye<sup>1</sup>, Qingqing Wei<sup>1</sup> and Yuanbo Liang<sup>1,2\*</sup>

<sup>1</sup>The Eye Hospital of Wenzhou Medical University and School of Ophthalmology and Optometry, China

<sup>2</sup>Wenzhou Medical University, Glaucoma Institute, Wenzhou, China

### Abstract

AB-interno Canaloplasty (ABiC) is one of the minimally invasive glaucoma surgeries for patients with Primary Open-Angle Glaucoma (POAG). The main mechanism is the enlargement of Schlemm's canal and the collector channels. There is less research on its unsuccessful rate and the possible reasons. Here we report 2 cases of elevated intraocular pressure and blockage of Schlemm's Canal (SC) orifice after ABiC surgery. We speculate that the reason for the failure is that the iris adhesion blocks SC orifice. Considering the effectiveness of internal drainage in 2 cases and the need to solve the problem of iris adhesion effectively, we performed a new procedure, which called penetrating canaloplasty, it is combining canaloplasty with trabeculectomy, iridectomy, but tightly closed the scleral flap. We speculated that aqueous humor through the SC orifice is a direct drainage way in ABiC to decrease the IOP, and iris adhesion may be the possible cause of the failure of part of SC surgery, and penetrating canaloplasty can be an option for patients after ABiC surgery.

**Keywords:** Blockage of Schlemm's Canal Orifice; AB-interno Canaloplasty; Primary open-angle glaucoma; Penetrating canaloplasty

### Introduction

Minimally Invasive Glaucoma Surgeries (MIGS) is safer and less traumatic surgical interventions for patients with mild-to-moderate glaucoma, and patients who are intolerant to standard medical therapy [1,2]. AB-interno Canaloplasty (ABiC), known as suture-free canaloplasty, is designed to access, catheterize, and viscoelastic expand all aspects of outflow resistance. Some studies indicate that ABiC is comparable to ab-externo Canaloplasty (CP) in lowering Intraocular Pressure (IOP) and medication dependency [3-4]. ABiC can reconstruct the physiological aqueous outflow channel for glaucoma patients, to reduce IOP, reduce or stop the use of anti-glaucoma medications; more and more hospitals carry out ABiC. However, few published data are describing the ABiC unsuccessful rate and the possible reasons, and no mentioned the follow-up treatment after ABiC failure. We report 2 cases of blockage of Schlemm's Canal (SC) orifice after ABiC surgery, and provide a feasible way (we named it penetrating canaloplasty) to treat patients with ABiC failure.

### Case Presentation

#### Case 1

A 62-year-old male presented in September 2018 with the increase of IOP OS. His ophthalmic history included Primary Open-Angle Glaucoma (POAG) OU for which he received cataract phacoemulsification and IOL implantation (Phaco and IOL) OD in April 2018.

On examination, the visual acuity was 20/40 OS, and IOP was 29.4 mmHg under two topical anti-glaucoma medications (brinzolamide and travoprost), and so, the patient was treated by Phaco and IOL and ABiC OS. The IOP was reduced to 10.3 mmHg on the first day after surgery.

However, this patient came back to the clinic and complained of a severe pain OS on the five days after surgery and an IOP of 42.2 mmHg. Adhesion of iris to the orifice of the SC was observed by gonioscopy (Figure 1A) and confirmed with AS-OCT (Figure 1B). To resolve the iris adhesion, the patient was put on a 2% pilocarpine eye drop immediately (q10x3). Two hours later, IOP was dropped to 19.5 mmHg OS. Re-examination of gonioscopy (Figure 1C) and AS-OCT (Figure 1D) revealed that the iris adhesions were pulled apart, and SC orifice was opened. The patient was continuously started on a 2% pilocarpine eye drop. Ten days later, the patient described the same symptom as the previous visit, and IOP was 38.0 mmHg OS. On gonioscopy, the SC orifice was

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#### \*Correspondence:

Yuanbo Liang, The Eye Hospital of Wenzhou Medical University, School of Ophthalmology and Optometry, 270, Xue Yuan Xi Road, Wenzhou, 325800, Zhejiang, China,

E-mail: yuanboliang@126.com

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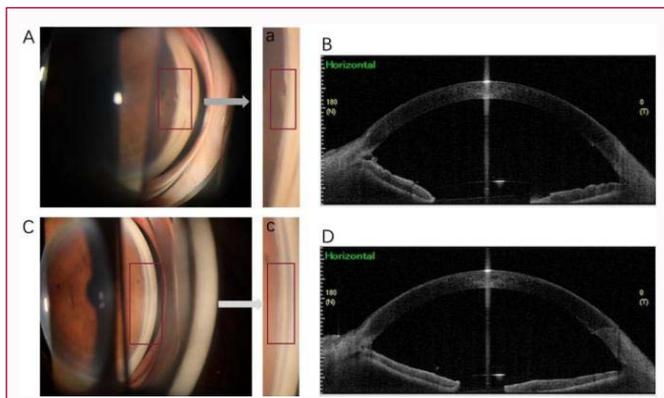
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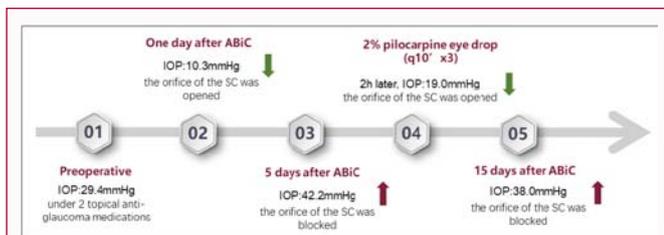
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**Figure 1:** Gonioscopy images and Anterior Segment Optical Coherence Tomography (AS-OCT) images in case 1. (A) The iris adhered to the orifice of the Schlemm's Canal (SC) on day five post-operatively. (a) Enlarged view at the 9 o'clock position of the adhesion site. (B) AS-OCT showed that the surgical orifice of SC was blocked on day five post-operatively. (C) The orifice of SC was opened after using a 2% Pilocarpine eye drop. (c) Enlarged view at the 9 o'clock position of the same site after using a 2% Pilocarpine eye drop. (D) AS-OCT showed that the orifice of the SC was opened after using a 2% Pilocarpine eye drop.



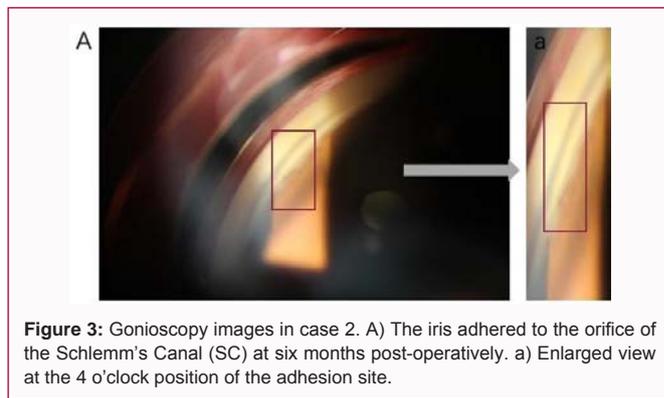
**Figure 2:** The describe of IOP and SC orifice after ABiC. ABiC: Ab-interno Canaloplasty; SC: Schlemm's Canal.

blocked.

The consideration of the future treatment is based on the following points (the describe of IOP, and SC orifice were shown in Figure 2).

1. The early effect of ABiC indicates that the SC and its distal structures are unobstructed.
2. After the pupil retracting agent opened the peripheral anterior synechia of the iris, the IOP decreased, but after the iris synechia happened again, the IOP increased, indicating that the distal structures are still unobstructed, and the key to the increase of IOP is the iris adhesion blocking the SC orifice.
3. It is almost impossible to solve the problem of iris synechia from the internal way. Even if the goniosynechialysis into practice, iris synechia may happen again.

The patient was treated by penetrating canaloplasty [5]. It is a new procedure, combining the canaloplasty with trabeculectomy, iridectomy, but tightly closed the scleral flap. The surgery steps include: make a 4 mm × 4 mm superficial scleral flap based on the fornix, and make a deep scleral flap about 2 mm × 2 mm size below it, peel forward to the SC and the SC is opened by the removal of the external wall, then insert the microcatheter into the SC and pushed forward within SC for the entire 360 degrees until it comes out of the other side. A 10-0 polypropylene suture tied the distal tip, and the microcatheter is withdrawn and pulled back through the SC in the opposite direction. A small amount of viscoelastic agent was delivered in SC at every two clock hours. The suture is then knotted under



**Figure 3:** Gonioscopy images in case 2. A) The iris adhered to the orifice of the Schlemm's Canal (SC) at six months post-operatively. a) Enlarged view at the 4 o'clock position of the adhesion site.

tension to distend the trabecular meshwork inwardly. Then the deep trabecular tissue (2 mm × 2 mm) was cut off at SC and forward, and the respective iris root was cut. Finally, the scleral flap was sutured as tightly as possible (2-4 stitches) without the use of anti-metabolic drugs. The conjunctival flap was closed to the watertight state by routine 10-0 nylon suture. With this procedure, the aqueous humor is drained from the anterior chamber through internal trabeculectomy to sub-scleral flap, and then go through the suture-expanded ostium of SC. Therefore, it can restore the physiological pathway of aqueous flow, avoiding a bleb-dependent outflow pathway, and preventing the anterior synechia of peripheral iris.

The IOP remained well controlled at 13.4 mmHg after 1 year post-operatively. No significant drop was noted in his visual acuity, and no considerable progression was showed in his visual field.

**Case 2**

A 63-year-old woman presented in January 2019 with a history of IOP increased OS. Her ophthalmic history included POAG OD treated by medications and then an ABiC surgery combined with Phaco and IOL in July 2018. She had a stable postoperative course with IOP in the six months.

On examination, IOP was 26.0 mmHg, and VA was 20/40. The gonioscopy examination found the blockage of SC orifice (Figure 3). For this patient, considering the effectiveness of internal drainage and the need to solve the problem of iris adhesion effectively, we performed penetrating canaloplasty, and the IOP remained well controlled at 12 mmHg at six months post-operatively.

**Discussion**

ABiC is a new minimally invasive glaucoma surgery developed based on CP. Like CP, ABiC involves all aspects of aqueous outflow, including the proximal and distal structures, which can reconstruct the natural outflow pathway of aqueous humor in mild-to-moderate POAG. Circumferential (360°) dilation of the SC and surrounding collector channels are the main mechanisms of IOP reduction in ABiC. The SC was expanded, and the aqueous humor outflow was increased. Moreover, ABiC is an ab-interno surgery avoiding scleral incisions and keeping conjunctiva [6]. The study found ABiC to have comparable glaucoma medication reduction and IOP lowering to CP in POAG [7]. However, ABiC has little research on its failure rate and causes.

Although the rise of IOP could be seen in some cases during the early postoperative period when referring to the CP, an increase of IOP to a significant level as the reported case seldom occurred. Several reports postulated that initial IOP spikes might be due to the

residual hyaluronic acid inside SC, which did not permit adequate outflow of aqueous humor to cross the trabeculodescemetic window and get into the collector channels until the hyaluronic acid was completely washed away. Early IOP spikes usually tended to be stabilized within 24 h to 48 h when the viscoelastic material was cleared [8-9]. In case 1 and case 2, the IOP increased in 5 days and six months after ABiC, respectively, which were unlikely to be related to the viscoelastic material used during surgery. Gonioscopy provided evidence that obstruction of the SC orifice by iris could be the cause, and led to an increase of IOP. Additionally, in case 1, after the use of 2% pilocarpine eye drops, the peripheral anterior synechia of the iris was opened, and the IOP of the patient was reduced, which further verified our hypothesis.

In general, the site of the highest resistance to aqueous outflow in POAG was thought to be at the Trabecular Meshwork (TM) and the inner wall of SC [10-12]. When the iris blocked the SC orifice, the outflow pathway was restored to the pre-operative status and thus causing IOP increase. Meanwhile, as IOP increases, the trabecular meshwork expands into the lumen of the canal and causes a simultaneous narrowing of the lumen, raising the possibility that this collapse might further cause a significant increase in outflow resistance [13].

From our cases, whether case 1 or case 2, the effectiveness of early ABiC shows that the SC and its distal structures are unobstructed. Iris adhesion blocked SC orifice causes IOP increased, iris adhesion relieved, IOP dropped. We hypothesize the direct drainage way of aqueous humor through the SC orifice is another mechanism behind ABiC to low the IOP. We think this direct drainage way is destroyed when there is any iris adhesion. Therefore, it is reasonable to conclude that the patency of the SC orifice may be one of the keys to a successful ABiC, at least for a portion of patients with POAG. As for the reason of iris tissue blocking the SC orifice, it is possible that the pressure gradient from the anterior chamber to the SC drives the iris to move towards the SC orifice and finally blocks the outflow pathway.

We performed penetrating canaloplasty in our cases. The intraoperative insert the microcatheter into the SC and can still push forward within SC for the entire 360 degrees, which also validates our hypothesis about the effectiveness of internal drainage in the two patients. We have made a preliminary study on the efficacy and safety of penetrating canaloplasty [5], which shows it is safe and effective surgery, despite the needs a longer follow-up. We treated 22 Primary Angle-Closure Glaucoma (PACG) patients. The preoperative IOP was  $38.0 \pm 11.9$  mmHg, and the mean postoperative IOP was  $15.7 \pm 5.0$  mmHg at 3 months and  $15.4 \pm 3.7$  mmHg at 6 months.

## Conclusion

We speculated that aqueous humor through the SC orifice is a direct drainage way to decrease the IOP. We would suggest that surgeons pay a particular focus on the situation of SC orifice when an increased IOP occurs in patients who have performed ABiC. Finally, when patients with stubborn iris synechia, penetrating canaloplasty is a way to solve this question.

## Patient Consent

Consent to publish this case report has been obtained from the patient in writing. This report does not contain any personally identifying information.

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