

Using triangular marks of capsulotomy edge for the alignment of Toric IOLs postoperation: a new technique

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Abstract

Background: Accurate alignment of Toric intraocular lens (IOL) axis is vital for achieving the desired astigmatic correction after surgery. We used a pair of triangular incision markers on anterior capsulotomy edge to assess the rotations of Toric IOL axis and compare with conventional manual corneal marker for postoperative follow-up.

Methods: Thirty-six cataract patients (39 eyes) were enrolled who underwent phacoemulsification and AcrySof Toric IOL implantation between May 2018 and August 2018. All patients coexist regular corneal astigmatism between 1.0 diopter(D) and 3.0D. The patients were divided to two groups according to the axial length. Axial length less than 26mm was named Group A. The other patients belong to Group B. Triangular incisions of anterior capsulotomy edge and conventional manual corneal marking method were used to measure the rotations of Toric IOL at 1 and 3 months after surgery.

Results: The angles of rotation for Toric IOL assessed by the new markers were less at 1 and 3 months for group A when compared with the conventional manual corneal marking but not for group B. There are not any intraoperative and postoperative complications by using the new technique.

Conclusion: The triangular markers in anterior capsulotomy edge are more accurate when compared with conventional manual corneal marking method to evaluate the rotation stability of Toric IOL after operation.

Background

Cataract surgery is no longer just a method for restoring visual acuity, but for achieving emmetropia[1]. The astigmatism correction has become an vital component which affects the postoperative visual quality [2]. Several researches showed that 41% patients with corneal astigmatism about 0.5-1.0 diopter(D), 27% patients with 1.0-1.5 D, and 15% to 29% patients with more than 1.5 D before surgery [3-6]. Many methods are commonly used to correct astigmatism during the surgery[7]. Although limbal, corneal relaxing incisions and LASIK are popular and good alternatives, problems such as poor predictability, injury of cornea with infection and visual regression may occur[8]. The implantation of Toric intraocular lens (IOL) can reduce preexisting astigmatism and increase the likelihood of spectacle independence[9-13].

The rotational stability of Toric IOL is closely related to its effect[14]. It's generally believed, each degree of Toric IOL misalignment loss 3.3% of astigmatic correction[15]. If the rotation over 30 degrees, extra astigmatism may occur[16]. Only when the axis of the IOL is accurately coincided with the maximum corneal refractive power line, the best correction can be provided. The accurate alignment of Toric IOL axis dependent on marks before and during surgery. In the early postoperative follow-up, accurate assessment of IOL axis position also raised much attention for surgeons.

Traditionally, the rotation of Toric IOL is calculated by the theoretical axis before surgery and the actual axis after surgery. There are several Toric IOL alignment methods included manual marking[17], iris-fingerprinting technique and intraoperative wavefront aberrometry[18]. Image-guided system also is an effect method to locate exact Toric IOL alignment[19]. However, the main challenge in Toric IOL misalignment is no longer IOL positioning during the surgical procedure, but rather the postoperative secondary IOL rotation. It is difficult for surgeon to estimate immediately Toric IOL axis rotation in follow-up due to lack reliable marker. Recently, an innovative way of providing Toric IOL alignment guidance is using laser capsulotomy to create a pair of small, opposite pointers or capsular marks on the capsular rim[20]. But due to its cost, the technology is difficult to development for developing country. The capsular marks also might lead to potential tear of capsular during surgery raised many concerns.

In current study, we created a pair triangular incision, a biological marker, on anterior capsulotomy edge during the surgery. Using the new technique, we measured the rotation degree of Toric IOL comparing with the traditional corneal marking measurement in follow-up.

Methods

This study was approved by the ethical committee of Affiliated Hospital of Nantong University. All procedures adhered to the tenets of the Declaration of Helsinki. All patients were willing to volunteer for the research and signed a written informed consent.

Thirty-six patients with cataract (39 eyes) who underwent routine phacoemulsification with AcrySof Toric IOL (Alcon Laboratories, Inc., Fort Worth, TX, USA) implantation between May 2018 and August 2018 were enrolled. All patients have regular corneal astigmatism between 1.0 D to 3.0 D. They did not have any eye diseases including corneal diseases, glaucoma, pterygium, ocular trauma, capsular calcification and abnormalities of suspensory ligament. Patients with intraoperative or postoperative complications also were ruled out.

Preoperative examinations

Routine preoperative examinations were performed for each patient in the study, including uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), slit-lamp biomicroscope examination, intraocular pressure, corneal topography (Pentacam HR; OCULUS Optikgeräte, Wetzlar, Germany), B-scan ultrasonography, IOL spherical power calculation (SRK/T formula from Lenstar LS900, Haag-Streit, Switzerland). Online Toric calculator software (Alcon, Inc., accessible at <http://www.acrysof-toriccalculator.com>) was utilized to calculate the IOL cylinder power, taking into account keratometry data (total corneal curvature from Pentacam), SIA and the position of the incision.

Surgical techniques

Half hour before the surgery, the location of incision and axial position of IOL were marked on the cornea closed to the limbus using a sterile marker pen under the slit beam in the slit lamp. The patient should sit

at the slit-lamp biomicroscope with head straight in the chin-rest and eyes focusing horizontally ahead.

Phacoemulsification was performed by one experienced surgeon(HJG) according to our previous research[21]. All patients were implanted an AcrySof SN6A Toric IOL (T2–T8, Alcon). Before incision hydration, we created a pair triangular incision on anterior capsulotomy edge aligning the axial mark on optic of the IOL(Fig.1). The post-operation therapies were tobramycin and dexamethasone (Tobradex; Alcon, USA) and diclofenac sodium eye drops (Difei, Qixin Pharmaceutical, China) three times a day for 2 weeks.

Postoperative assessment

Postoperative examinations were conducted 1 and 3 months after surgery to assess Toric IOL rotation. The photos were taken when the diameter of pupil was no less than 6 mm under slit-lamp biomicroscope.

Image analysis

The photographs were analyzed using tools in Adobe Photoshop (version 7.0). Using the “survey tool”, a straight line vertically crossed the center of pupil as the axis of 90 degree (Line1, Fig.2). Straight line by connected axial mark on optic of the IOL showed the actual astigmatic axis right now (Line2, Fig.3). Straight line by connected two triangular markers in the anterior capsule showed the astigmatic axis put in the surgery (Line3, Fig4). Through line1, line 2 and the calculated astigmatic axis before surgery, we had the theoretical rotation. Through line 2 and line 3, we had the actually rotation of the IOL. Every line was made three times to take the mean value.

Statistical analysis

SPSS version 17.0 was used for statistical analysis. Measurement data were shown in form of mean \pm SD; Variance analysis was performed to compare the differences between two groups. *P* value <0.05 was considered for statistical significance.

Results

All surgeries were successfully completed and no intraoperative complications occurred. For all 39 eyes, the rotations of Toric IOL after surgery were different between two methods. The least difference was 0.1 degree and the largest was 3.3 degrees.

One month after surgery

After surgery, the average rotation of Toric IOL assessed by conventional method one month was 4.582 ± 2.337 degrees by, and by triangular markers on capsulotomy edge was 3.649 ± 1.648 degrees ($p = 0.0478$). According to the axial length, we divided all patients to two groups. Axial length less than 26mm was named Group A. The other patients belong to Group B. In the group A, the average rotation by conventional method was 3.907 ± 1.903 degrees, and by triangular markers on capsulotomy edge was

3.028±1.292 degrees ($p = 0.047$). In the group B, the average rotation by conventional method was 6.54±2.389 degrees, and by triangular markers on capsulotomy edge was 5.45±1.177 degrees ($p = 0.235$).

Three months after surgery

The average rotation of Toric IOL assessed by conventional method one month after surgery was 5.189±2.664 degrees, and by triangular markers on capsulotomy edge was 4.118±1.948 degrees ($p = 0.0498$). In the group A, the average rotation by calculated axis was 3.245±1.291 degrees, and by triangular markers on capsulotomy edge was 4.259±2.008 degrees ($p = 0.029$). In the group B, the average rotation by calculated axis was 7.89±2.486 degrees, and by triangular markers on capsulotomy edge was 6.65±1.315 degrees ($p = 0.202$).

Discussion

In current study, we designed a new method to assist cataract surgeons in aligning Toric IOLs after operation. There are several methods to marked target meridian for Toric IOL implantation. Traditionally, the axis of Toric IOL is marked on the cornea close to the limbus under the horizontal beam of slit-lamp. However, the method is associated with several errors, such as smudging of ink, too broad or imprecise markings and uncorrected parallax [22]. All those mentioned problems may lead a misalignment of Toric IOL and imprecise to estimate the rotation after surgery.

The VERION image-guided system is a new surgical-assisted platform in recent years. Preoperative corneal curvature data can be integrated with anterior segment imaging for intraoperative registration. Real-time visual image marking under microscopy can facilitate the placement of Toric IOL during surgery. The method is an accurate and fast procedure resulting in precise Toric IOL alignment compared with the traditional corneal marking. However, it also is not very convenient for postoperative follow up.

In the study, we created a pair of biological markers on anterior capsulotomy edge during the surgery. It is simple and safe method to assess the rotation degree in follow-up. The rotation of Toric IOL measured by the markers was less compared with the traditional method. The difference could be found one month after operation. There are several reasons for the difference. The first, each scale of slit-lamp beam covers 5 degrees. Therefore, non-integers of axis could only be estimated which might exaggerate the actual rotation degree. The second, Adobe Photoshop software can be accurate to 0.1 degree and measured the angles three times to avoid potential inaccuracy.

The axis length is a very important factor for rotation of Toric IOL [23]. Therefore, we compared different axis length of patients. Interestingly, the rotations are larger than group A at one and three months after surgery in group B (≥ 26 mm). We did not find any difference between the two methods. Recently, the capsular marks created by the LENSAR laser platform were introduced [20]. However, the marks were created by femtosecond laser in porcine eyes. The cost for LENSAR laser platform also is a limitation for widespread application of the technology.

There are some limitations should be discussed furtherly in the method. The continuous curvilinear capsulorhexis (CCC) should be made in 5.0mm instead of 5.5mm. The smaller CCC may cause contraction of the anterior capsule which may lead the IOL tilt and decentration. Syringe needle is lower cost than capsule scissors or vitreous cutters. However, potential risks of capsule tear might occur in the surgery. An experienced surgeon may avoid the risk to keep stability of the anterior chamber during aspiration. We also found the mark disappear due to the contraction of capsule in the longer follow-up. The markers could be created again by YAG laser.

Conclusions

Compared with the traditional method, the markers on anterior capsulotomy edge are more convenient and accurate for estimating the rotation stability of Toric IOL.

List Of Abbreviations

D: diopter; IOL: intraocular lens; UCVA: uncorrected visual acuity; BCVA: best corrected visual acuity; CCC: continuous curvilinear capsulorhexis

Declarations

Ethics approval and consent to participate

The study approved by the institutional ethics committee of Affiliated Hospital of Nantong University and was performed according to the tenets of the Declaration of Helsinki. All patients were willing to volunteer for the research and signed a written informed consent.

Consent to publish

Not applicable

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' Contributions

YW and YX wrote the manuscript. JW and PPL participated in data analysis. HJG conceived the research, and critically reviewed the manuscript and interpreted the data. All authors read and approved the final manuscript.

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Table

Rotation degree of different measurements in one and three months

	triangular marker		conventional manual marker	
	1 month	3 months	1 month	3 months
All eyes (39 eyes)	3.649±1.648*	4.118±1.948*	4.582±2.33*	5.189±2.664*
Group A (29 eyes)	3.028±1.292*	4.259±2.008*	3.907±1.903*	3.245±1.291*
Group B (10 eyes)	5.45±1.177	6.65±1.315	6.54±2.389	7.89±2.486

*P<0.05

Figures

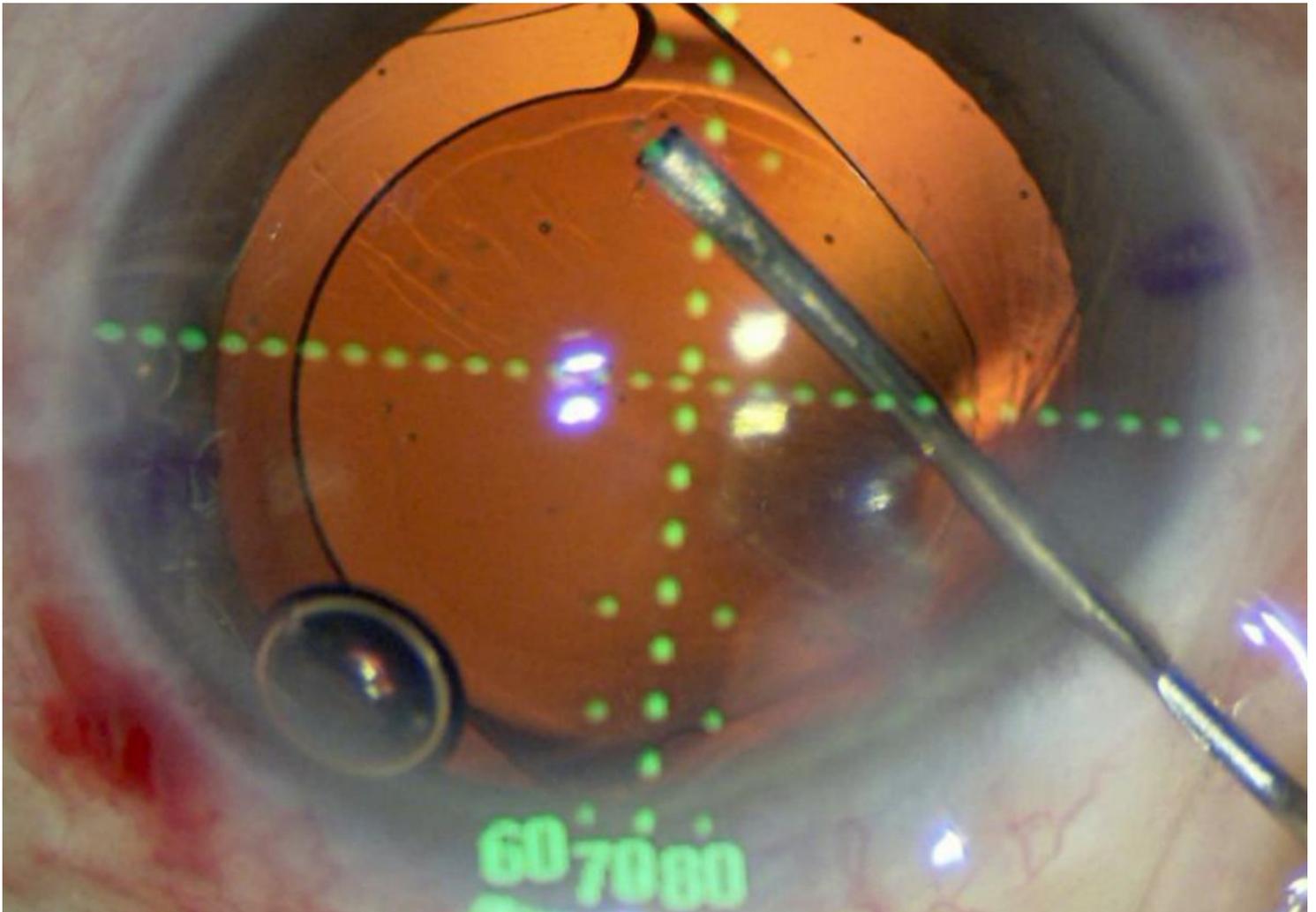


Figure 1

Made a triangular marker with syringe needle on anterior capsulotomy edge

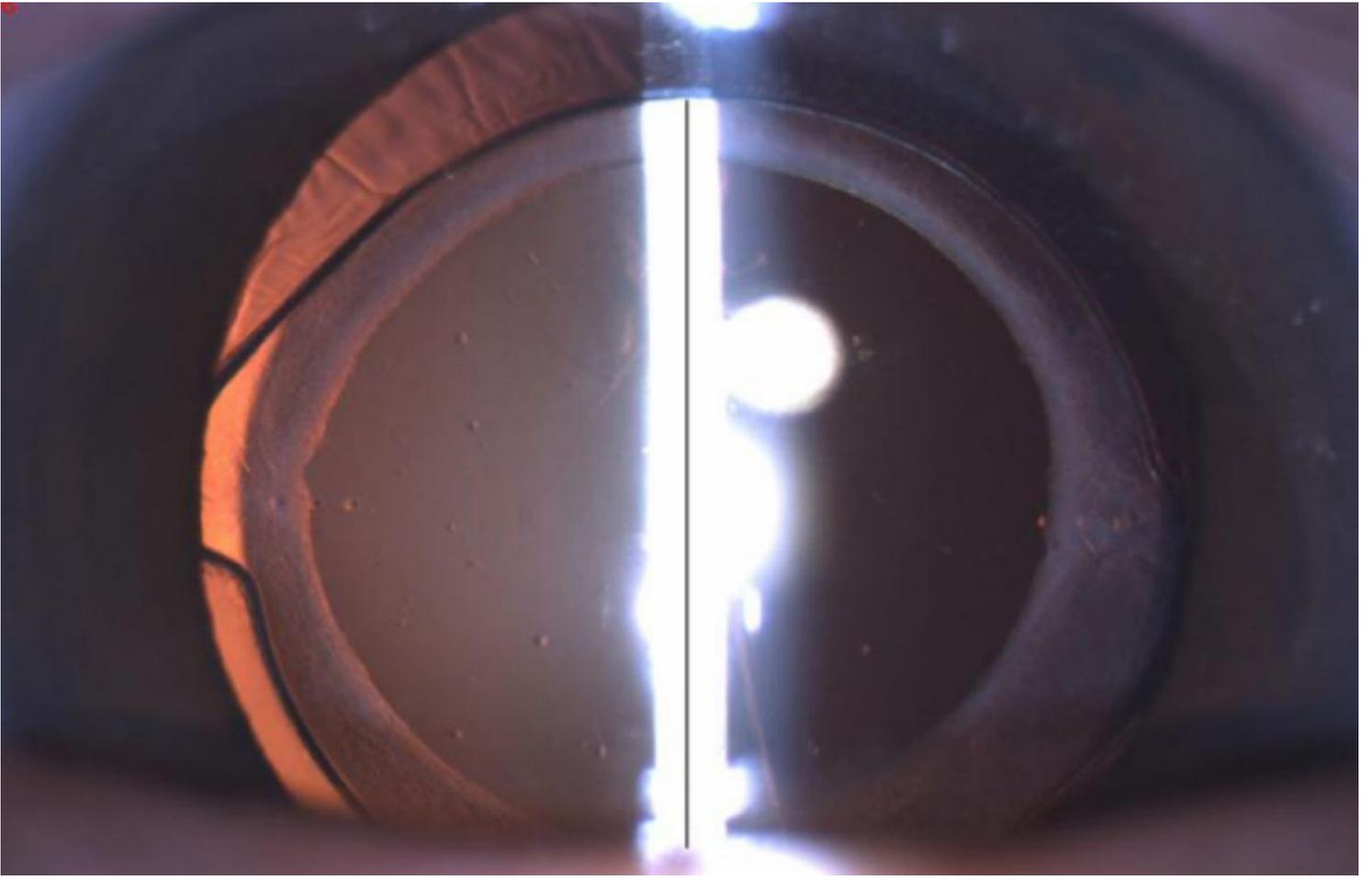


Figure 2

Line 1. Straight line vertically crossed the center of pupil showed the 90° axis.

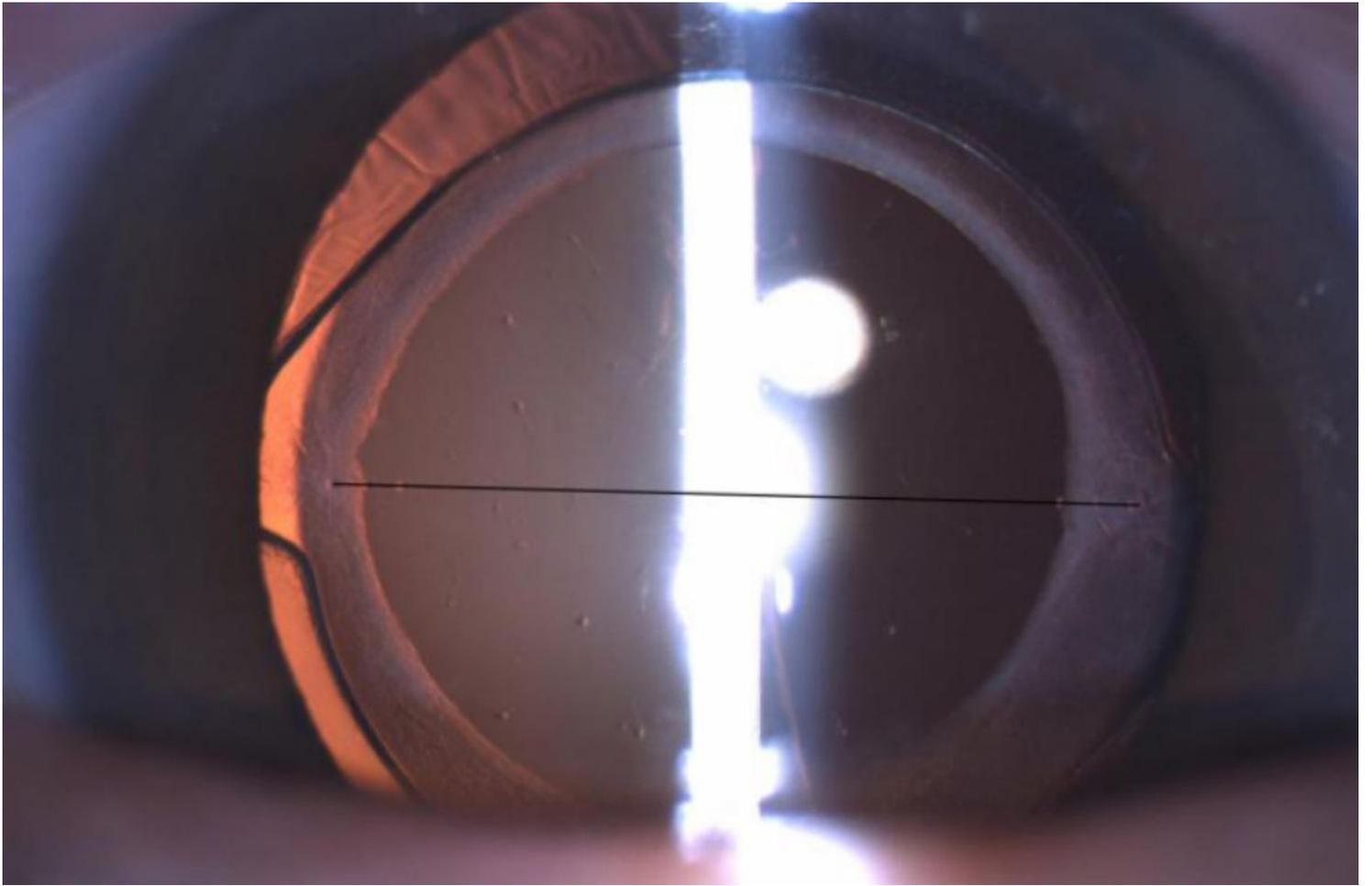


Figure 3

Line 2. Straight line by connected axial mark on optic of the IOL showed the actual astigmatic axis right now.

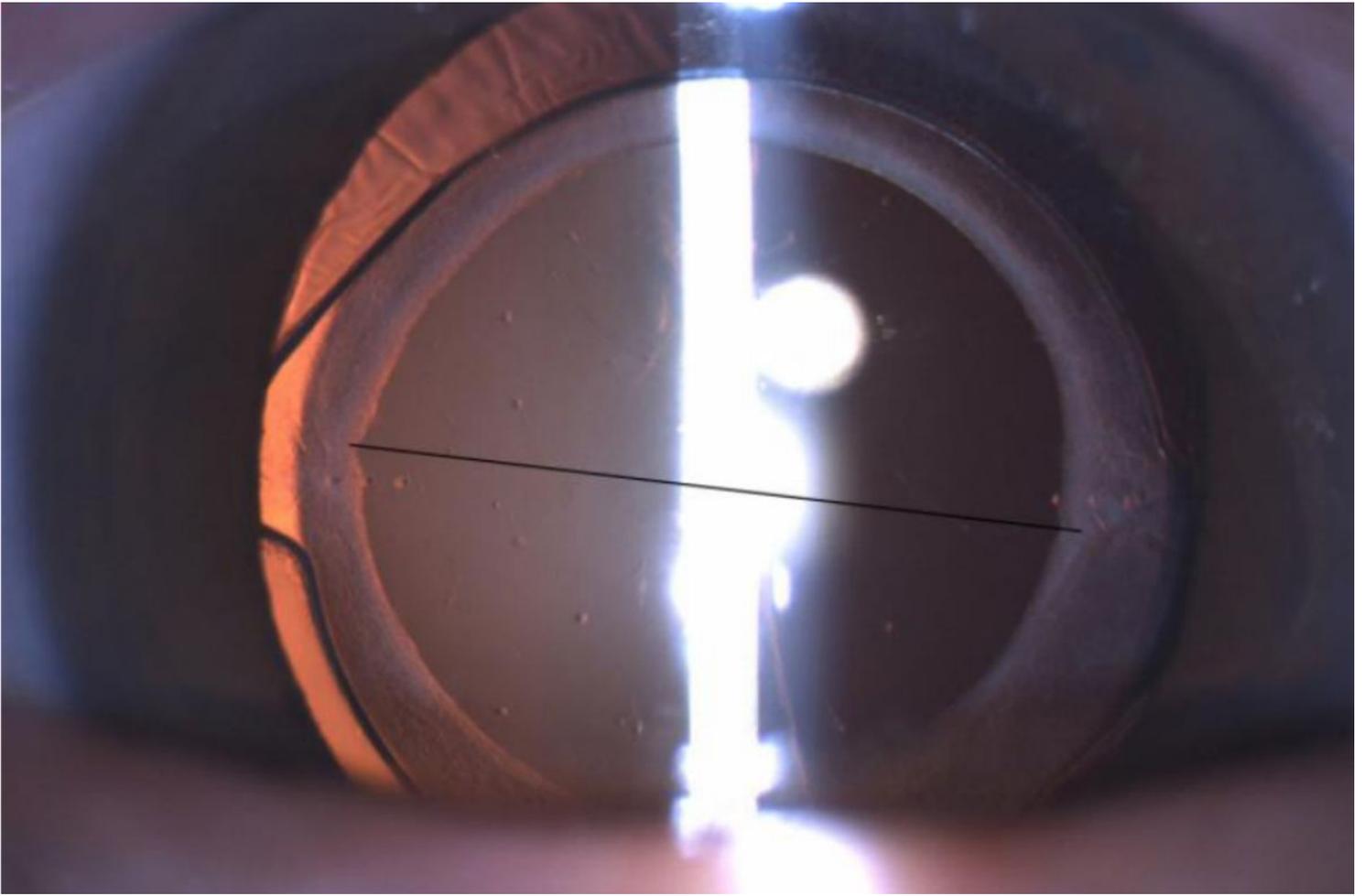


Figure 4

Line 3. Straight line by connected two triangular markers on anterior capsulotomy edge showed the astigmatic axis in the surgery