CASE REPORT

Intraocular pinhole implantation for irregular astigmatism after planned and unplanned posterior capsule opening during cataract surgery

Bruno L.C. Trindade, MD, PhD, Fernando C. Trindade, MD, PhD, Claudio L.C. Trindade, MD

We present two cases for which intraocular pinhole implants were used to treat irregular corneal astigmatism after planned and unplanned posterior capsule opening during cataract surgery. The first case had a fibrotic posterior capsule that was eliminated with a posterior capsulorhexis. After that, the intraocular lens (IOL) and pinhole were implanted in the capsular bag. In the second case, a posterior capsule tear after phacoemulsification was converted to a posterior capsulorhexis, allowing implantation of an IOL in the capsular bag and the intraocular pinhole in the ciliary sulcus. With this method, irregular astigmatism in both cases could be managed with the intraocular pinhole very effectively. The implants remained stable and well centered in both cases and no complications were noticed.

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Online Video

Irregular corneal astigmatism is known to degrade uncorrected (UDVA) and corrected (CDVA) distance visual acuities. It can be caused by numerous conditions such as trauma, keratoconus, previous corneal surgery as in radial keratotomy and penetrating keratoplasty, or iatrogenic post-laser in situ keratomileusis ectasia. At present, there are several strategies to overcome corneal irregularity. The standard treatment for this condition relies on the use of rigid gas-permeable (RGP) contact lenses; however, their use can be limited in some patients. Intrastromal ring segments implantation, topography-guided excimer ablation, and customized crosslinking, among others, are some of the surgical alternatives presently available.[1–7] We have published a new way of addressing irregular corneal astigmatism with the use of an intraocular pinhole (Xtrafocus, Morcher GmbH) implanted in the ciliary sulcus of pseudophakic eyes.[8,9] By decreasing the aperture size, the intraocular pinhole is able to minimize the impact of higher-order aberrations caused by the irregular cornea. Although this device was developed to be implanted in the ciliary sulcus of pseudophakic eyes, we have demonstrated that it can also be implanted inside the capsular bag without major difficulties.[10]

In-the-bag intraocular lens (IOL) implantation is the current preferred technique for IOL positioning. However, the capsular bag must be preserved to allow such implantation. Posterior capsule rupture can occur in different stages of phacoemulsification, and its incidence is reported to be less than 1% in experienced hands.[11,12] In such cases, in-the-bag IOL implantation might be precluded. To overcome this complication, it has been shown that converting a posterior capsule tear into a posterior continuous capsulorhexis allows one to better distribute forces in the posterior capsule, preventing the tear from enlarging and allowing implantation of the IOL in the bag.[11,13]

We present two cases of irregular corneal astigmatism caused by different conditions in which an intraocular pinhole was used even after a posterior capsular opening. In one case, an intentionally primary posterior capsulorhexis was performed to clear the visual axis from a densely fibrotic capsule. In the other case, the posterior capsule ruptured during phacoemulsification; however, we were able to convert it into a posterior capsulorhexis. In both cases, the IOL was implanted in the bag after the implantation of the intraocular pinhole to address corneal irregular astigmatism. To our knowledge, this is the first study in which a small-aperture diaphragm was used after posterior capsule opening.

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From Cançado Trindade Eye Institute (B.L.C. Trindade, F.C. Trindade, C.L.C. Trindade), Medical Sciences School of Medicine (B.L.C. Trindade), Medical Sciences University Hospital Eye Institute (B.L.C. Trindade), Belo Horizonte, and the University of São Paulo (C.L.C. Trindade), Brazil.

Corresponding author: Bruno Lovaglio Cançado Trindade, MD, PhD, Rua Manaus, 595, Belo Horizonte, MG, 30150-350, Brazil. Email: bruno.trindade@ioct.org.

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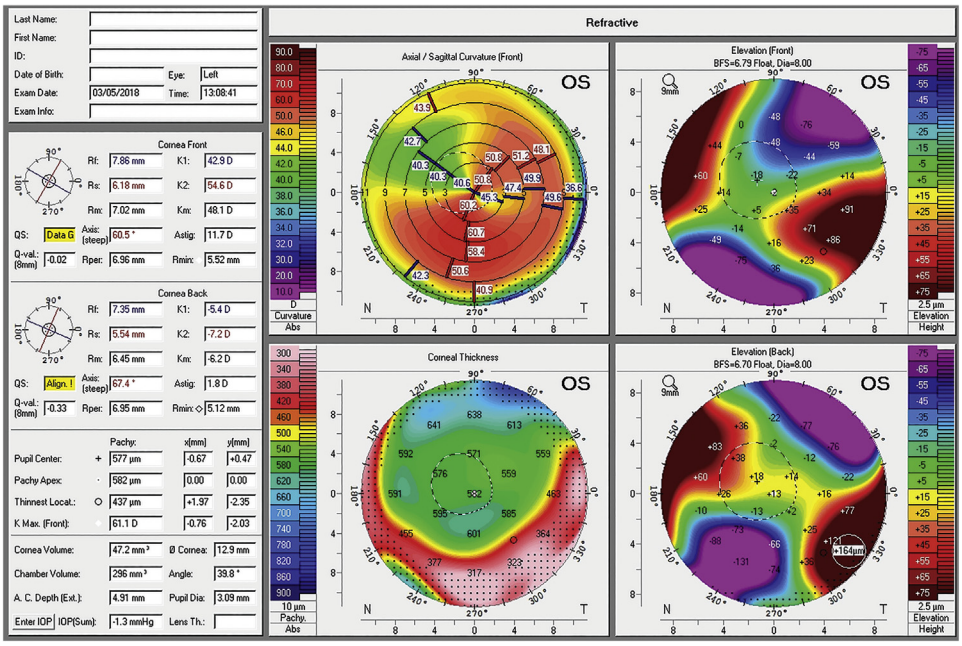

Figure 1. Corneal tomography of the left eye (Case 1). Notice the irregular astigmatism and thinning of the graft–host junction inferiorly.

CASE REPORTS

Case 1

A 31-year-old man presented with severely decreased visual acuity in the left eye because of a very dense posterior subcapsular cataract. The patient had undergone penetrating keratoplasty in the left eye 9 years earlier as a treatment for keratoconus, but he developed high corneal irregular astigmatism. The UDVA was counting fingers in the right eye and hand movement in the left eye. The CDVA in the right eye was 20/100 with −6.00 −6.00 × 90 and the visual acuity in the left eye had no improvement with refraction. The patient was using an RGP contact lens in the right eye to further improve his visual acuity to 20/50 on presentation. Although having reported the use of topical steroids in numerous occasions in the left eye, he was not using any topical medication at the time of presentation. Biomicroscopy of the left eye showed a clear and well-centered graft with mild inferior graft–host junction thinning. The lens had a white cataract with a very dense posterior subcapsular component. Fundoscopy was impossible to perform in this eye, but a B-scan showed an attached retina with no other relevant findings. The central corneal thickness, which was assessed using an ultrasound pachymeter (DGH 500 Pachette, DGH Technology, Inc.), was 580 µm in the left eye. Corneal tomography (Pentacam HR, OCULUS Optikgeräte GmbH) was performed and showed an irregular and steep graft. The anterior corneal astigmatism was 11.7 diopters (D), according to the simulated keratometry (Figure 1).

Consent was given for cataract surgery associated with the implantation of an intraocular pinhole.

The surgery was performed under a peribulbar block. After phacoemulsification and cortical removal, a very densely fibrotic posterior capsule was noted, even after aggressively polishing (Figure 2).

A decision was then made to perform a primary posterior capsulorhexis. After opening the posterior capsule centrally with a 27-gauge needle, a dispersive ophthalmic viscosurgical device (OVD) (sodium hyaluronate 3.0%–chondroitin sulfate 4.0% [Viscoat]) was injected in the Berger space to push the anterior hyaloid face back. The posterior capsule was then grasped with an Ultrata forceps and a curvilinear posterior capsulorhexis was performed (Figure 3).

Next, the single-piece IOL was implanted in the capsular bag and the intraocular pinhole was also positioned inside it. At the end of surgery, the OVD was thoroughly removed, the single incision was sutured, and dexamethasone was injected in the subconjunctival space (Figure 4).

On the day after the surgery, the patient already had a significant improvement in visual acuity despite a central graft edema.

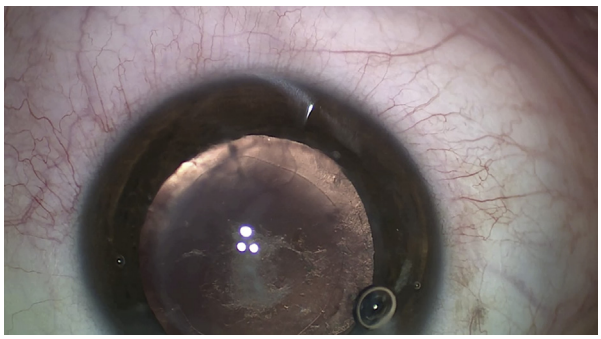

Figure 2. The fibrotic posterior capsule after aggressive polishing (Case 1).

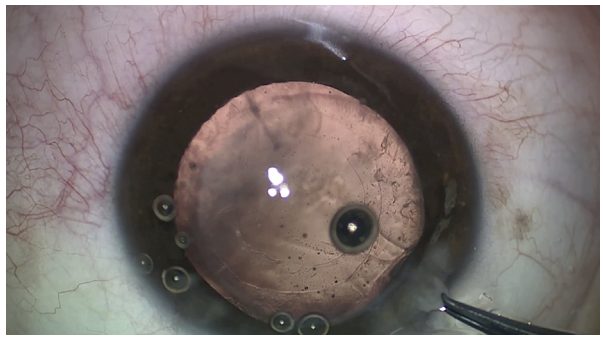

Figure 3. Posterior capsulorhexis performed to clear the visual axis (Case 1).

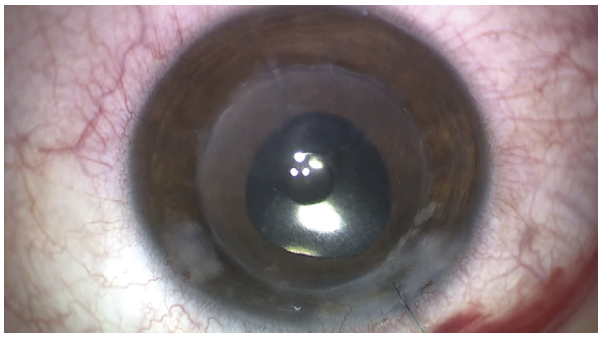

Figure 4. Case 1, final aspect of surgery.

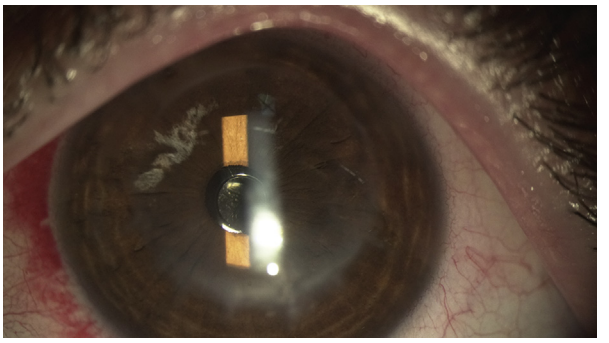

Figure 5. Case 1, 4 days after surgery. Note the well-centered pinhole.

The UDVA was 20/40 and the uncorrected near visual acuity (UNVA) was Jaeger 5 (J5). Both implants were well positioned, and moxifloxacin 0.5%–dexamethasone phosphate 0.075% (Vigadexa) 4 times a day was prescribed. Three days later, the graft was much clearer, and the UDVA had improved to 20/20 and J2 (Figure 5). Video 1 (Available at http://jcrsjournal.org) shows the key aspects of the surgery.

Because of the characteristics of the intraocular pinhole material, it is possible to see through the occluded part of the implant if using infrared light. In this way, infrared biomicroscopy was performed using a modified slitlamp and it was determined that both implants were extremely well centered. The limits of the posterior capsulorhexis were also visible (Figure 6).

The moxifloxacin was stopped and dexamethasone 0.1% (Maxidex) was prescribed and tapered weekly after the first week.

Six months later, the patient was extremely satisfied with the final result. The UDVA was 20/40 and the UNVA was J3, improving to 20/30 with $+2.50\ -4.00 \times 160$ (Figure 7).

Figure 8 shows the automated perimetry after surgery. The patient had stopped using the RGP contact lens in the right eye.

Case 2

A 47-year-old man with cataract associated with keratoconus presented with a progressive decrease of visual acuity in the left eye for the past 3 years that was attributed to a myopic shift due to a nuclear cataract. The patient had been diagnosed with keratoconus since adolescence and he was dependent on RGP contact lenses in both eyes for the past 25 years, although his tolerance to them had been decreasing over time. He had undergone intrastromal ring segments implantation associated with corneal crosslinking in the right eye 2 years previously. However, both segments had to be explanted because of superficial erosion a few months later. On presentation, the UDVA was 20/200 and the UNVA was J16 in the right eye and 20/800 and J7, respectively, in the left eye. The CDVA was 20/120 with $-0.50\ -6.00 \times 10$ in the right eye and 20/100 with $-6.00\ -3.50 \times 80$ in the left eye. Pinhole visual testing improved vision to 20/40 in both eyes. Biomicroscopy showed a superior paracentral corneal scar in the right eye secondary to the ring segment's extrusion. The left eye had an initial nuclear cataract with no other abnormalities in the anterior segment. A fundus examination showed no abnormalities in either eye. Corneal tomography (Pentacam HR, OCULUS Optikgeräte GmbH) showed a clear pattern of keratoconus with irregular astigmatism and inferior steepening (Figure 9).

Ocular biometry, which was performed using optical laser interferometry (Lenstar, Haag-Streit AG), showed that the axial length was within normal ranges in both eyes. Therefore, informed consent was obtained to perform cataract surgery associated with intraocular pinhole implantation.

The surgery was performed under a peribulbar block. After creating a 2.2 mm superonasal clear corneal incision, an anterior capsulorhexis was performed with the assistance of hyaluronate 3.0%–chondroitin sulfate 4.0% (Viscoat) OVD. At the end of phacoemulsification, a posterior capsule tear was discovered in the paracentral portion of the bag (Figure 10).

Cortical removal together with anterior vitrectomy was performed to clear the strands of vitreous that had migrated anteriorly. After complete removal of the vitreous, an Ultrata forceps was used to grasp the edge of the torn posterior capsule and tear it circumferentially until a posterior continuous curvilinear capsulorhexis was completed (Figure 11).

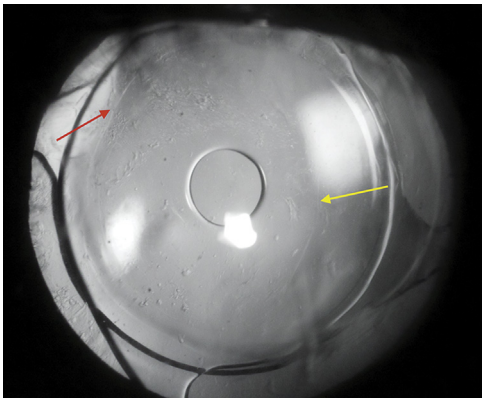

Figure 6. Infrared biomicroscopy (Case 1). Note the limits of the anterior capsulorhexis (*red arrow*) and posterior capsulorhexis (*yellow arrow*, behind the intraocular pinhole).

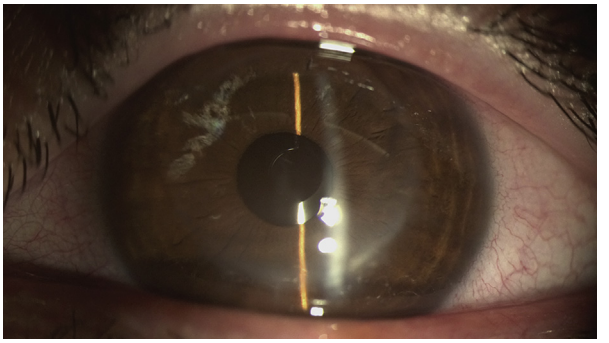

Figure 7. Case 1, 6 months after surgery.

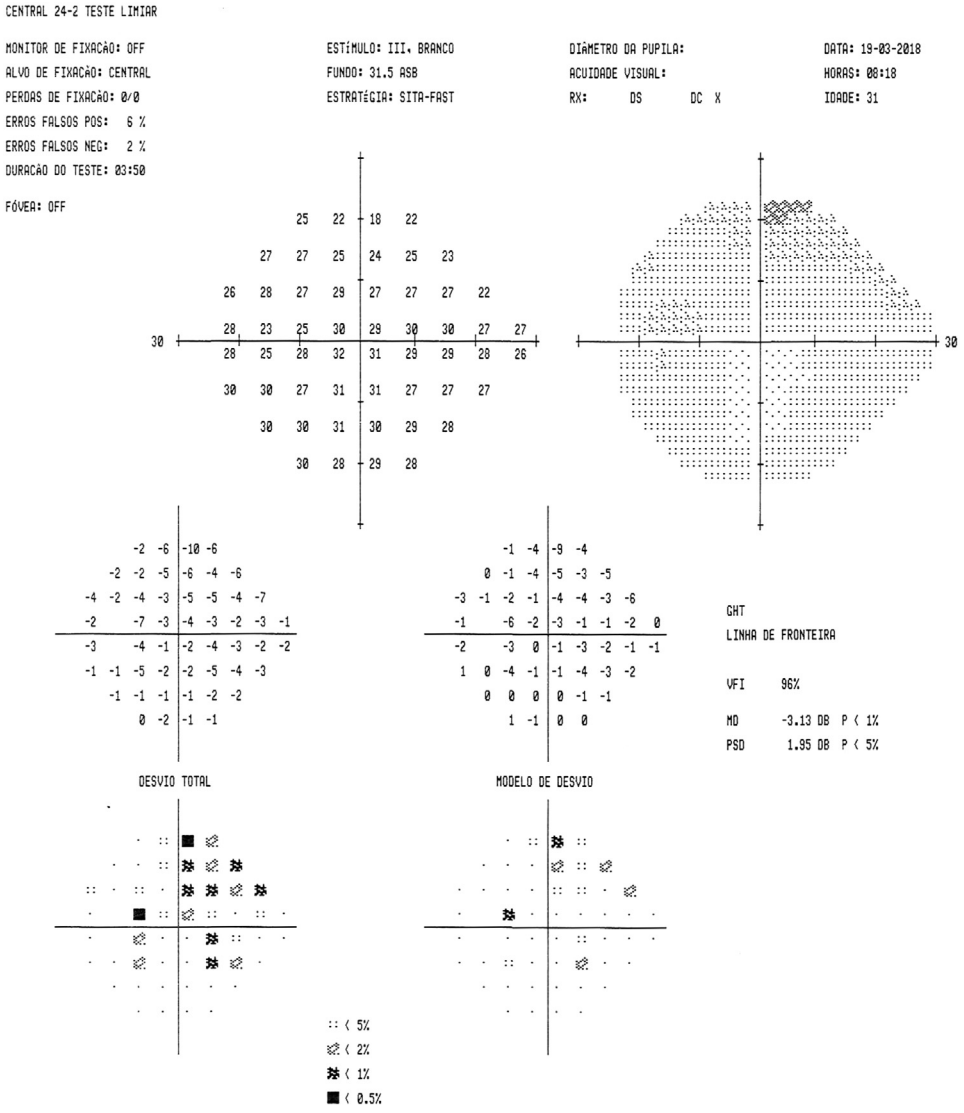

Figure 8. Postoperative visual field (Case 1). No clinically relevant finding was noted.

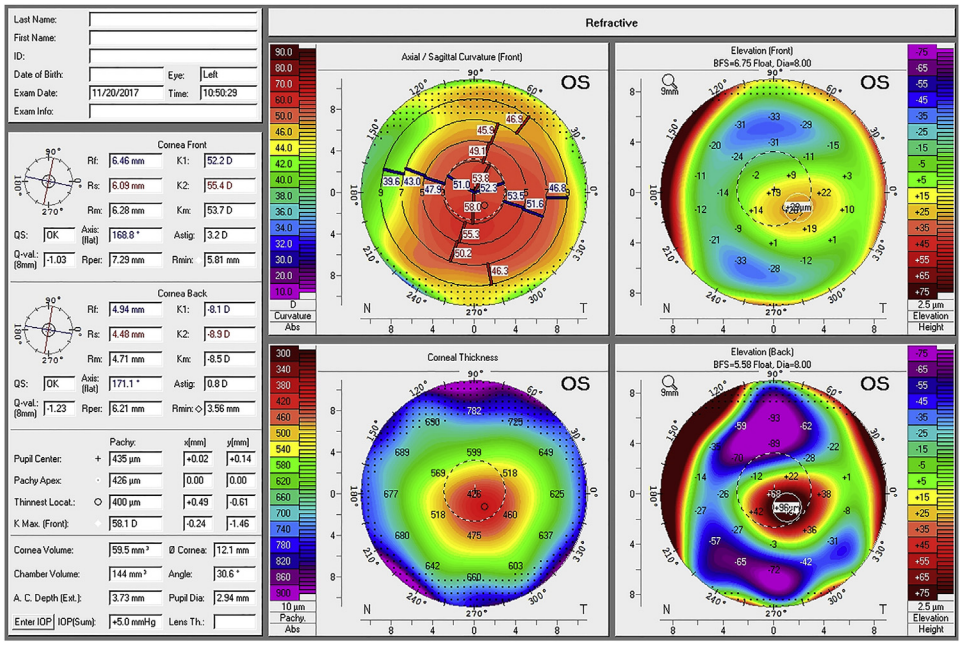

Figure 9. Corneal tomography of the left eye (Case 2). Note the irregular corneal astigmatism.

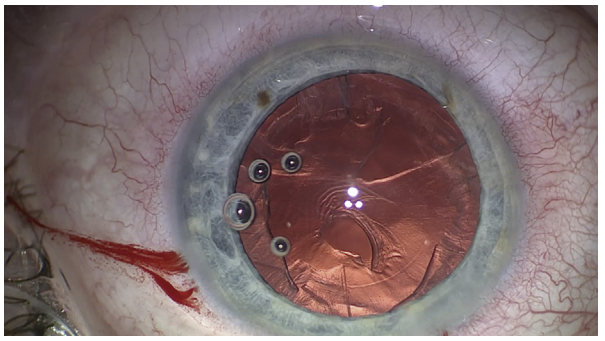

Figure 10. Posterior capsule rupture noted after completion of phacoemulsification (Case 2).

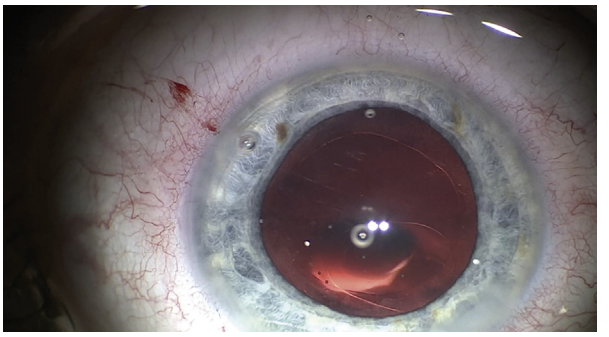

Figure 11. Posterior capsule tear converted to a posterior capsulorhexis (Case 2).

With the assistance of super-cohesive OVD (sodium hyaluronate 2.3% [Healon 5]), a +7 D single-piece hydrophobic acrylic IOL (ZCB00, Johnson & Johnson) was carefully implanted in the capsular bag. Following that, the intraocular pinhole was implanted in the ciliary sulcus (Figure 12).

The surgery was then terminated after complete OVD removal, acetylcholine 1% (Miochol) injection, and wound suturing (Figure 13). Video 2 (Available at http://jcrsjournal.org) highlights the primary steps of this surgery.

Moxifloxacin 0.5%–dexamethasone phosphate 0.075% (Vigadexa) 4 times a day and nepafenac 2% (Nevanac) twice daily were prescribed. On the day after the surgery, the patient had significant improvement in the uncorrected visual acuities. The UDVA was 20/25 and the UNVA was J3. The cornea was clear and the intraocular pinhole was well centered. Infrared biomicroscopy was performed and both implants were determined to be very well centered. The posterior capsulorhexis was also visible in the superior nasal aspect of the posterior capsule (Figure 14).

The moxifloxacin was stopped 1 week after surgery, and the dexamethasone 0.1% (Maxidex) was tapered down for 4 weeks. Nepafenac was used for 30 days after the procedure. Despite that a small-aperture device was implanted, macular optical coherence tomography (Spectralis, Heidelberg Engineering GmbH) and an ultrawide field retinography (Optomap, Optos North America) were able to be performed 2 weeks after the surgery. Both examinations were entirely normal (Figures 15 and 16).

Ten weeks later, the patient remained very satisfied with his vision and there was a subtle further improvement in his visual acuity. At this point, the patient's UDVA was 20/25, the UNVA was J2, and the CDVA was 20/20 with plano −6.00 × 10. The intraocular pressure remained stable throughout the entire postoperative course and there were no signs of increased intraocular inflammation.

DISCUSSION

Irregular corneal astigmatism can be challenging to treat, especially in patients who cannot tolerate the use of RGP contact lenses. Corneal transplantation can be an option; however, this procedure might have an unpredictable outcome and long-term complications. The implantation of an intraocular pinhole after cataract surgery has been demonstrated as a method to successfully manage some of these patients.[8] However, for the optimal results of this technique, the pinhole has to be well centered at the end of surgery.

Posterior capsule rupture is a known complication of cataract surgery. Its incidence increases with a dense nucleus, poor visualization, an insufficiently dilated pupil, previous posterior segment surgery, and the surgeon's inexperience.[14] Even in the best hands, it can still occur and its incidence can reportedly occur up to 1% in routine cases.[11,13] With proper management, a posterior chamber IOL can still be implanted in the capsular bag after such a complication. This is the ideal place for implantation given that centration is better achieved, the effective lens position is more predictable, and there is protection against uveal tissue contact.

We have presented two cases in which an IOL was implanted in the capsular bag followed by the implantation of an intraocular pinhole after the posterior capsule had been opened. In one patient, the opening of the posterior capsule was unintentional, in the other, it was purposely

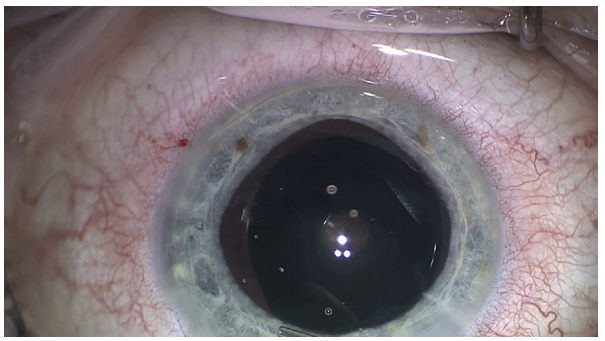

Figure 12. Implantation of the intraocular pinhole in the ciliary sulcus (Case 2).

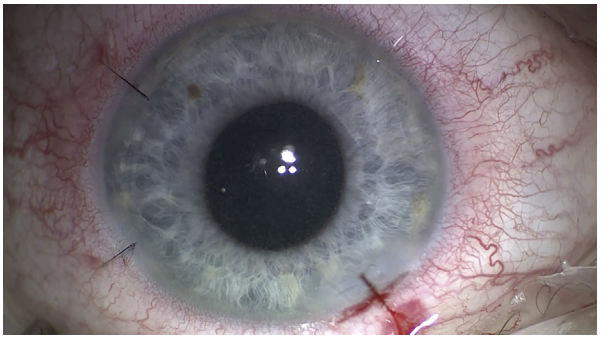

Figure 13. Aspect of the eye at the end of surgery (Case 2). Note the well-centered intraocular pinhole.

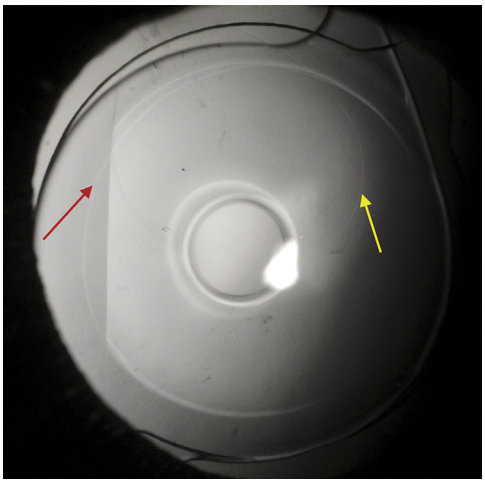

Figure 14. Infrared biomicroscopy (Case 2). Note margins of the anterior (*red arrow*) and posterior (*yellow arrow*) capsulorhexes, both located behind the occluded implant.

executed. In both cases, a posterior capsulorhexis was performed. By making the opening on the posterior capsule continuous, there is a better force distribution, allowing implantation of an IOL in the capsular bag without the risk for enlarging such an opening. This was especially important in our cases because we had planned to use a second implant. The Xtrafocus supplementary intraocular pinhole was designed to be implanted in the ciliary sulcus of pseudophakic eyes as a primary or secondary implantation.[8] However, we have also demonstrated a successful implantation in the capsular bag.[10] Regardless of where they are implanted, these devices require a near emmetropia refraction and good centration to achieve the desired outcome. In the two cases presented, we were able to achieve excellent centration of the pinhole after a posterior capsule opening and a remarkable improvement in visual acuity in both patients. With the aid of infrared biomicroscopy, we could visualize the proper alignment of the intraocular pinhole. Visual field constriction was not reported by any of the patients. Although there might be a slight reduction in the overall sensitivity, the effect of a well-centered intraocular pinhole in the visual field is not clinically relevant. In both cases, the implant remained stable and well centered in the postoperative period with no signs of ocular disturbances.

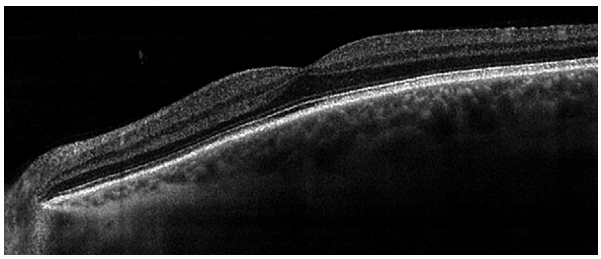

Figure 16. Macular optical coherence tomography (Case 2). There were no difficulties with performing this examination because it operates in the infrared spectrum.

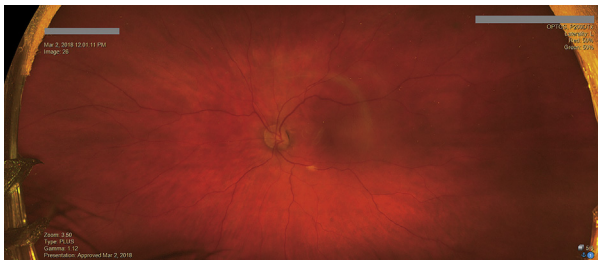

Figure 15. Ultrawide field retinography (Case 2). Note the ability to see the peripheral retina through the central pinhole.

In conclusion, intraocular pinhole implantation can be safely performed after posterior continuous capsulorhexis. Posterior capsulorhexis allows the use of the capsular bag as a site for implantation of the IOL and pinhole. Visual rehabilitation can be achieved in eyes with irregular corneal astigmatism with the use of the intraocular pinhole, even in scenarios of posterior capsule opening.

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Disclosures: *Dr. C.L.C. Trindade holds a patent for the intraocular pinhole device and has a license contract with Morcher GmbH. None of the other authors has a financial or proprietary interest in any material or method mentioned.*