CASE REPORT

Toric intraocular lens combined with a supplementary pinhole implant to treat irregular corneal astigmatism

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A case of refractive lens exchange with the implantation of a supplementary intraocular pinhole (IOPH) to treat a challenging case of keratoconus is presented. Four months after the initial procedure, an intraocular lens (IOL) exchange (under the IOPH) was performed to a toric implant to correct the residual manifest astigmatism. This significantly improved both distance and near acuities and demonstrates how a toric IOL and astigmatism correction in combination with a pinhole device could be used to treat selected cases of keratoconus.

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Small-aperture optics are gaining popularity because of their versatility to provide an extended range of vision as well as to correct irregular corneal astigmatism.[1] At present, there are 2 small-aperture options commercially available. The IC-8 intraocular lens (IOL) (AcuFocus) is a single-piece, hydrophobic acrylic foldable IOL with a pinhole mask embedded into its optic. The pinhole aperture is 1.36 mm, and the outer mask diameter is 3.23 mm. It was designed to be implanted into the capsular bag to extend depth of focus by flattening the defocus curve, allowing good vision through a wider distance interval.[2] The XtraFocus intraocular pinhole implant (Morcher GmbH) is a pinhole diaphragm made of foldable hydrophobic acrylic with a 1.3 mm central opening with no dioptric power. It was designed to be implanted in the ciliary sulcus of pseudophakic eyes to minimize the impact of irregular corneal astigmatism and can be used primarily at the time of cataract surgery as well as secondarily as a standalone procedure. Although both implants are fundamentally different, they have been demonstrated to share some properties in treating irregular corneal astigmatism.[3–5]

Irregular corneal astigmatism is a challenging condition that can result from numerous situations. Previous corneal surgeries such as radial keratotomy, penetrating keratoplasty, and postlaser in situ keratomileusis ectasia, diseases such as keratoconus and pellucid marginal degeneration, and trauma are known causes of irregular corneal astigmatism. The treatment options rely on the use of rigid gas-permeable contact lenses being fit over the cornea or the sclera. Surgical options are limited and might have an unpredictable result with intracorneal ring segment implantation, topography-guided laser ablation, and customized corneal crosslinking as the main options.[6–8] We and others have demonstrated the benefit of using small-aperture optics in these cases.[3–5,9] The reduction of aperture minimizes the impact of peripheral aberrant light rays and allows better visual acuity.

Although correction of small cylinder might not be necessary when using small-aperture devices, large cylindrical errors may still compromise the improvement of vision with an intraocular pinhole. We present a case in which we performed a refractive lens exchange with implantation of a nontoric IOL combined with the XtraFocus intraocular pinhole to treat keratoconus. Four months later, we had to exchange the primary IOL under the pinhole for a toric IOL; this significantly improved the uncorrected vision of the patient. We believe that this case illustrates the benefit of a high-cylinder correction IOL combined with an intraocular pinhole to treat irregular corneal astigmatism, and, to our knowledge, this is the first report that highlights this approach.

CASE REPORT

A 41-year-old man presented with decreased visual acuity due to keratoconus in both eyes. He underwent corneal crosslinking in his right eye over 10 years previously to halt disease progression, and 5 years later, he had intracorneal ring segments implanted in the same eye with no visual benefit according to his perception. All these procedures were performed elsewhere, and no records were available. He relied on rigid gas-permeable contact lenses to improve

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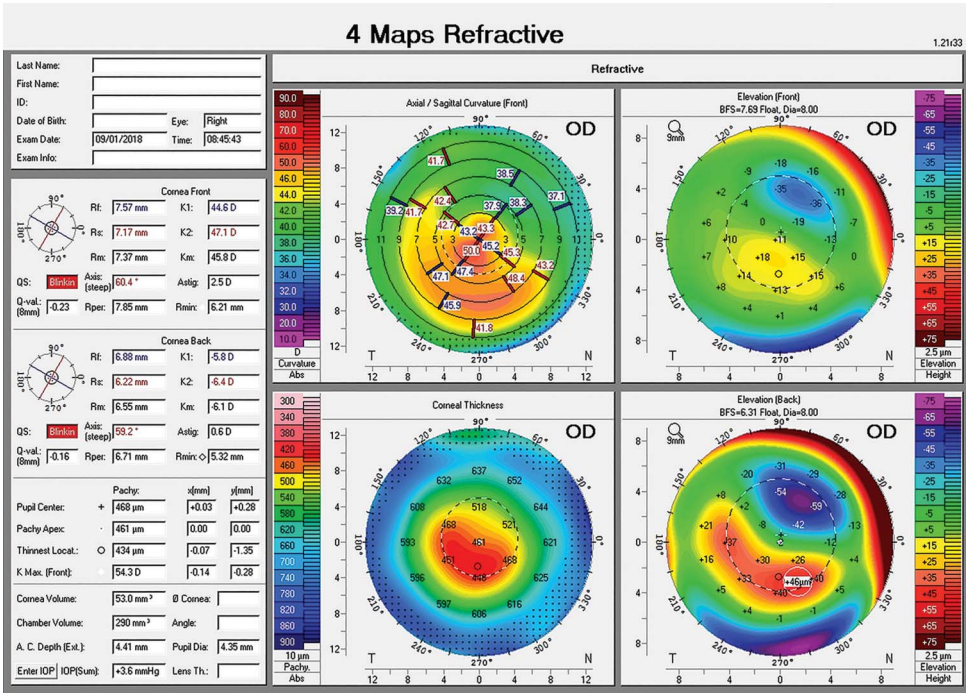

Figure 1. Preoperative corneal tomography of the right eye.

his vision, but due to recurrent and refractory giant papillary conjunctivitis, he was now unable to wear them. His uncorrected distance visual acuity (UDVA) was 20/800 in the right eye and 20/400 in the left. The corrected distance visual acuity (CDVA) in the right eye was 20/50 with +1.00 −6.00 × 75 and 20/50 with −1.50 −6.00 × 10 in the left eye. However, due to aniseikonia, he was not able to wear spectacles and was penalizing the right eye. Biomicroscopy revealed clear corneas in both eyes with 2 intracorneal ring segments implanted in the posterior third of the stroma in the right eye. His lenses were clear, and his mesopic pupils were approximately 6.0 mm in diameter. No abnormalities were found in the posterior segment examination. Corneal tomography (Pentacam HR, Oculus Optikgeräte GmbH) showed a noticeable keratoconic pattern in both eyes classified as stage 2 in the Amsler-Krumeich scale (Figure 1). Consent was given to perform a refractive lens exchange associated with a monofocal IOL implantation in the capsular bag together with the intraocular pinhole in the ciliary sulcus.

Surgery was performed under a peribulbar block. After a 2.2 mm clear corneal incision, hyaluronate 3.0%–chondroitin sulfate 4.0% ophthalmic viscosurgical device (OVD) was injected into the anterior chamber. A manual curvilinear capsulorhexis was made with a diameter of approximately 5.0 mm. Lens aspiration was followed by cortical cleanup and anterior and posterior capsule polishing. A +8.0 diopter (D) SN60WF IOL (Alcon) was implanted in the capsular bag, and the type 90L XtraFocus pinhole was placed in the ciliary sulcus. Surgery concluded after removal of OVD and placement of a safety suture in the main incision (Figure 2). Moxifloxacin 0.5%–dexamethasone phosphate 0.1% (Vigadexa, Alcon) 4 times a day for 1 week and nepafenac 2% (Nevanac, Alcon) twice daily for 1 month were prescribed. No postoperative complications were noticed.

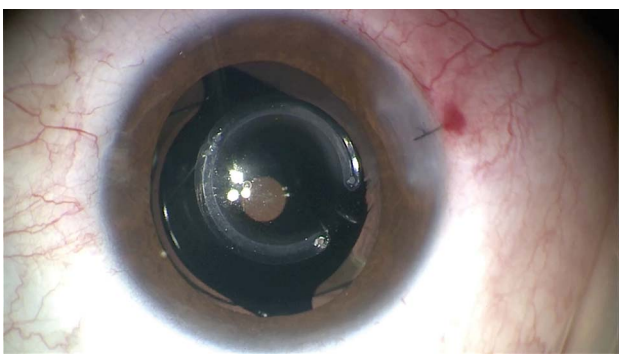

Figure 2. Aspect of the eye at the end of surgery. Note the well-centered intraocular pinhole.

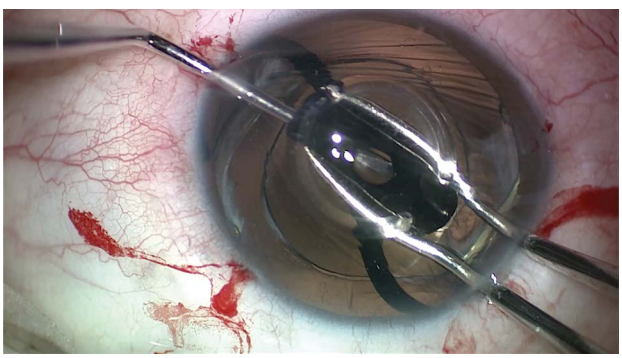

Figure 3. Intraocular pinhole being folded for explantation prior to intraocular lens exchange.

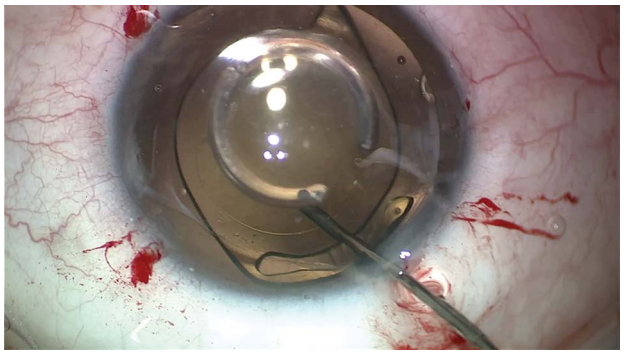

Figure 4. Toric intraocular lens properly aligned at the correct planned meridian.

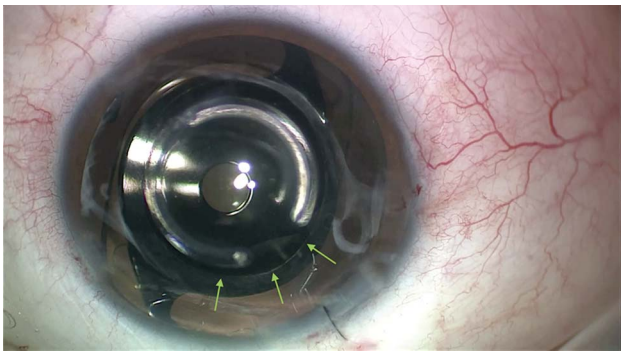

Figure 5. Aspect of the end of surgery. *Green arrows* show capsulorhexis margins over the intraocular pinhole.

Two weeks later, the UDVA had improved to 20/80, and the CDVA was 20/30 with +1.00 −5.00 × 135. Spectacles were prescribed, and it was hoped that the intraocular pinhole would help alleviate the aniseikonia previously experienced by the patient. However, 4 months later, his uncorrected acuity was 20/60 and J10. His BCDVA was 20/20 with +3.00 −5.00 × 135, but he was still complaining of the aniseikonia and of his uncorrected near vision. His complaints were severe enough that we decided to perform an IOL exchange under the intraocular pinhole to a high-cylinder toric IOL 4 months after the initial operation.

This surgery was also performed under a peribulbar block. After reentering the eye, the anterior chamber was inflated with dispersive OVD. The intraocular pinhole was carefully dialed out of the sulcus, folded, and explanted with minimal difficulties (Figure 3). A 27-gauge needle was used in the OVD syringe to help reopen the capsular bag. After the bag was reinflated, blunt dissection was used to free the fibrosis around the IOL haptics. The IOL was then positioned in the anterior chamber, folded, and explanted. Careful capsule polishing was then performed, and a capsular tension ring was inserted to ensure complete bag dissection and better force distribution. A +11.0 D toric IOL (SN6AT9, Alcon) was then inserted and aligned to the correct orientation (Figure 4). OVD was then removed from behind the implant. The intraocular pinhole was then reimplanted, and this time, it was positioned inside the capsular bag together with the primary IOL. After removal of the OVD from the anterior chamber and placement of a safety suture in the main incision, surgery was concluded (Figure 5). Moxifloxacin 0.5%–dexamethasone phosphate 0.1% (Vigadexa) 4 times a day for 1 week and nepafenac 2% (Nevanac) twice daily for 1 month were again prescribed.

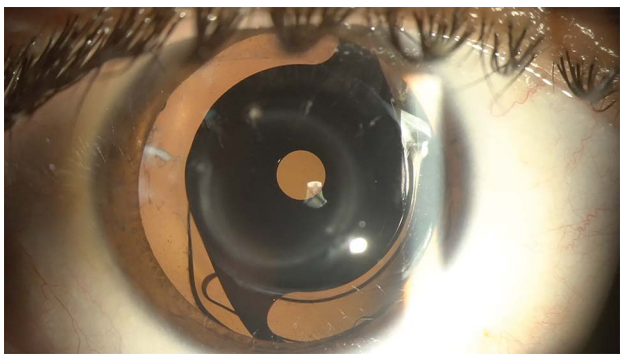

Figure 6. Postoperative biomicroscopy reveals both implants very well centered.

On the following day, the patient reported a significant improvement in his vision. His uncorrected acuity was 20/16 and J2, and he was very satisfied with the result. One week later, biomicroscopy revealed both implants well centered (Figure 6). By using a modified infrared slitlamp, it is possible to see through the black pinhole, and it was noticed that the toric marks precisely aligned in the planned axis (Figure 7).

Nine months later, the patient reported decreased visual acuity. His UDVA was 20/50, and during biomicroscopy, we noticed signs of posterior capsule opacification (Figure 8, A). This was addressed by Nd:YAG laser, which could be normally performed through the central part of the pinhole (Figure 8, B). One week after the laser procedure, his UDVA was improved to 20/20 J1 and Figure 9 shows the aspect of the eye 1 year after the IOL exchange.

DISCUSSION

The use of small-aperture optics has been recently described as an alternative surgical method to treat irregular corneal astigmatism. It allows improvement of vision by eliminating aberrant peripheral light rays. These eyes have a compromised image resolution that is more pronounced the more irregular the cornea is. The combination of an aberrant cornea and a large pupil is disastrous to image quality, and limiting the entrance aperture of the eye improves vision in these cases.

We presented a case in which a supplementary pinhole implant was used together with a toric IOL to significantly improve vision in a patient with keratoconus. This case is particularly interesting because it highlights the importance of astigmatism correction even when using a small-aperture device. Because a nontoric IOL was used in the initial surgery, the limitations of this approach could be easily seen. Despite an improvement in the CDVA, the patient was still impaired by the manifested residual mixed astigmatism. An IOL exchange was performed to a high-cylinder-correcting toric IOL, under the intraocular pinhole, and this significantly

Figure 7. Infrared biomicroscopy showing the correct alignment of the toric implant behind the black pinhole.

improved the final outcome. The combination of the correction of the astigmatism given by the toric implant and the flattening effect on the defocus curve introduced by the intraocular pinhole allowed an improvement in both distance and near uncorrected acuity.

IOL exchange was possible even with the intraocular pinhole placed in the ciliary sulcus. The pinhole had to be removed before any attempt to reopen the capsular bag, and this was performed with minimal difficulties. The haptics of the XtraFocus implant are designed to be supported in the ciliary sulcus with round edges, a thin profile, and a very polished surface.[10] This way, they are very well tolerated by the uveal tissue, and no fibrosis was noted around them. Various techniques of IOL exchange have been published, but they all share the same basic principles. The capsular bag has to be reopened, and this can be performed with the assistance of a dispersive OVD. After that, the IOL has to be carefully dissected from the fibrosis that can occur around the haptics, and once this is completed, it can be folded or cut before removing it through a small incision.

It is known that small-aperture optics can minimize the effect of low corneal astigmatism without the need of toric IOLs. However, when high corneal astigmatism is present (and this is not uncommon in irregular corneas), it should be corrected with a toric IOL to achieve the best possible outcome. Although the pinhole can minimize the effect of small astigmatism, the

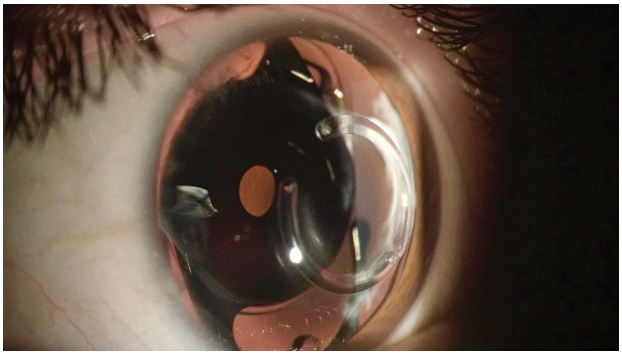

Figure 9. One year after intraocular lens exchange.

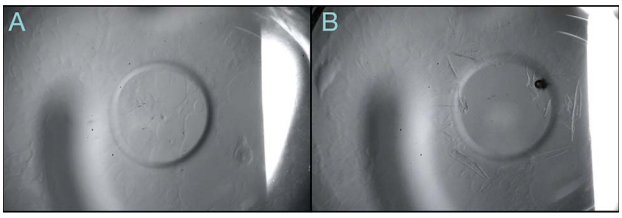

Figure 8. Infrared biomicroscopy 9 months after intraocular lens exchange. *A*: Note the posterior capsule opacification before laser treatment. *B*: Minutes after uneventful Nd-YAG laser posterior capsulotomy.

presence of a cylinder of over 2.0 D will compromise the result of any procedure involving small-aperture optics.

The importance of the pinhole can be questioned by some in this case arguing that the refractive lens exchange (RLE) by itself might be the responsible for the improvement achieved. The use of toric IOLs during RLE in patients with keratoconus has been described before and has been shown to effectively reduce refractive astigmatism and improve uncorrected visual acuity.[11] However, its use is limited to patients that have an adequate preoperative vision with spectacles.[11] In fact, the best-corrected vision is usually maintained or minimally improved after surgery. Moreover, a large pupil size significantly interferes with the level of higher-order aberrations in the eye and might limit the resulting uncorrected and corrected visual acuity in eyes with irregular corneas. In our opinion, pupil size is often overlooked by surgeons, and it can account for suboptimal results after any procedure in patients with irregular astigmatism.

In patients with smaller pupils and with only mildly irregular corneas, RLE alone (with or without a toric IOL) might be enough to significantly improve vision, and in these cases, this should be tried first. It is also important to mention that the XtraFocus intraocular pinhole can always be implanted secondarily if it becomes necessary. Our patient had a preoperative corrected acuity limited to 20/50 and a mesopic pupil of 6.0 mm. We do not believe that the RLE alone (even with a toric IOL being used) would be able to improve vision much further than the preoperative CDVA. In fact, we believe that it is the combination of these 2 procedures, lens replacement and intraocular pinhole implantation, was what made such an improvement possible. Their complement effect can further improve the results obtained by either individually, especially in selected cases of keratoconus. IOL replacement decreases myopia and astigmatism, and the pinhole minimizes the higher-order aberrations. It is important to point out that the central part of the cornea must be transparent for this approach. Any central corneal opacity will compromise the result.

Complications from using 2 acrylic IOLs in the capsular bag have been described, especially the formation of an interlenticular membrane that can degrade vision.[12] However, we have recently published the safety of using the XtraFocus pinhole inside the capsular bag together with an IOL.[13] We did not see any signs of interlenticular membrane formation in any of the patients with a follow-up of up to 4 years. We hypothesize that the pinhole allows the flow of

aqueous humor through it and the meniscus shape of this implant vaults over the primary IOL, leaving the interface clean. And by implanting the pinhole in the capsular bag, we could get a better centration of the device overtime when compared with sulcus fixation.

The IC-8 IOL is an appealing alternative for this approach; however, the lack of a toric model as well as the current limitation of the dioptric power availability (+15.5 D to +27.5 D) might limit its use in these more complex cases. We feel that the manufacturer should consider these implementations to further expand its use to these cases of irregular corneas.

The major concern of this approach is developing and monitoring any vitroretinal pathology. RLE, particularly in younger individuals, has been shown to increase the risk for developing retinal detachments, especially in longer myopic eyes.[14,15] In addition, the small-aperture device can hinder proper retinal evaluation. To overcome this, it has been shown that the XtraFocus pinhole is made of a polymer that is transparent to infrared light and can be used to examine the posterior segment with infrared-operating equipment, such as optical coherence tomographers. Moreover, the alternative surgical procedure left for these patients is usually limited to a corneal graft. This procedure, by itself, has its own set of risks that are probably less favorable in the long term with a less reliable outcome.

In conclusion, the combination of RLE with the use of a toric IOL and the implantation of a supplementary pinhole might significantly improve vision in cases of keratoconus. This is a new approach to treat this disease and could be useful in a selected group of patients who are intolerant to contact lenses.

WHAT WAS KNOWN

- Small-aperture optics might improve vision in cases of irregular corneas due to keratoconus.
- The decreased aperture might compensate for some small residual astigmatic errors.

WHAT THIS PAPER ADDS

- The use of a high-cylinder toric intraocular lens (IOL) might improve vision even in cases where an intraocular pinhole is used.
- Astigmatism correction with a toric IOL was shown by the significant improvement of vision after IOL exchange.

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Disclosures: *Dr. C.L.C. Trindade has a licensed contract with the manufacturer of the XtraFocus intraocular pinhole. None of the other authors has a financial or proprietary interest in any material or method mentioned.*

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