

Implantation of a small-aperture intraocular lens in patients with abnormal corneas

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ABSTRACT:

Purpose: This study aims to evaluate the clinical outcomes of implantation of the IC-8 small-aperture intraocular lens in patients with abnormal corneas undergoing cataract surgery.

Methods: This retrospective case series included 5 patients (6 eyes) with irregular corneal pathology who underwent phacoemulsification with implantation of the IC-8 intraocular lens in the capsular bag. Preoperative assessment included manifest refraction, corrected and uncorrected visual acuity, corneal tomography, and slit-lamp examination. Postoperative evaluation included visual acuity, refractive status, and subjective visual quality. **Results:** All eyes underwent uncomplicated phacoemulsification and successful implantation of the IC-8 lens. Postoperatively, patients demonstrated improvement in visual acuity and functional vision despite the presence of irregular corneal astigmatism. The pinhole optics of the IC-8 lens appeared to reduce the impact of higher-order aberrations associated with ectatic and post-keratoplasty corneas. No intraoperative or significant postoperative complications were observed during follow-up.

Conclusions: Implantation of the IC-8 small-aperture IOL may represent a valuable option in selected patients with abnormal corneas, including keratoconus and post-keratoplasty eyes undergoing cataract surgery. The lens design may improve visual performance by increasing depth of focus and minimizing the effects of corneal irregularities.

KEYWORDS: IC-8; small-aperture intraocular lens; cataract surgery; irregular cornea; keratoconus; keratoplasty.

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I. INTRODUCTION

Management of cataract in patients with abnormal corneas remains surgically and optically challenging. Irregular corneal astigmatism and higher-order aberrations, commonly encountered in conditions such as keratoconus or following corneal transplantation, often limit postoperative visual quality and reduce the predictability of refractive outcomes. Conventional monofocal lenses may not adequately address these optical imperfections, while multifocal lenses are generally avoided because corneal irregularity could further compromise visual quality. [6,7,10]

The IC-8 intraocular lens (IOL) is a hydrophobic acrylic posterior chamber IOL incorporating small-aperture optics based on the pinhole principle. It has an overall diameter of 12.5 mm, the biconvex aspheric optic is 6.0 mm in diameter with a 360-degree square posterior edge. The lens features an embedded opaque annular mask with an outer diameter of 3.23 mm and a central aperture of approximately 1.36 mm, designed to selectively filter peripheral unfocused light rays while allowing central focused rays to reach the retina. By limiting peripheral defocused and aberrated light rays, the small-aperture design increases depth of focus and may improve tolerance to residual refractive error and corneal irregularity. [1,4,5,6]

The small-aperture concept may be particularly advantageous in eyes with irregular corneal optics, where reduction of higher-order aberrations can lead to improved retinal image quality. [6]

In this study, we report the outcomes of IC-8 IOL implantation in 5 patients (6 eyes) with abnormal corneas undergoing phacoemulsification for cataract. The cohort included patients with keratoconus and one patient with prior keratoplasty. We evaluate the clinical outcomes and patient satisfaction in this challenging patient population.

II. PATIENTS AND METHODS

For this retrospective study we analysed the data from 5 patients and 6 eyes with abnormal corneas and visually significant cataract. All procedures were performed at a single ophthalmology center by one experienced cataract surgeon.

Eligible eyes presented with a dense cataract associated with irregular corneal pathology resulting in reduced optical quality. The cohort included patients with keratoconus and one patient with previous corneal transplantation. All patients were considered unsuitable for multifocal intraocular lenses because of irregular corneal astigmatism and increased higher-order aberrations.

Preoperative assessment included measurement of best-corrected visual acuity (BCVA), slit-lamp biomicroscopy, corneal topography, optical coherence tomography (OCT) and optical biometry using the IOLMaster 700. Corneal imaging was used to evaluate the degree and pattern of corneal irregularity and to assist in surgical planning. Retinal OCT was performed to exclude concomitant macular pathology that could limit postoperative visual outcomes. Accurate IOL power calculation can be particularly challenging in highly irregular corneas. Previous studies of IC-8 implantation have demonstrated limitations of conventional keratometric approaches at very high keratometric values. [6,7]

We are attaching corneal topography scans of all 6 eyes of our patients, showing the severe corneal irregularities and ectasias. The scans demonstrate the extreme values of K1 and K2 and the associated astigmatism, correlating with the low vision and the limited postoperative result.

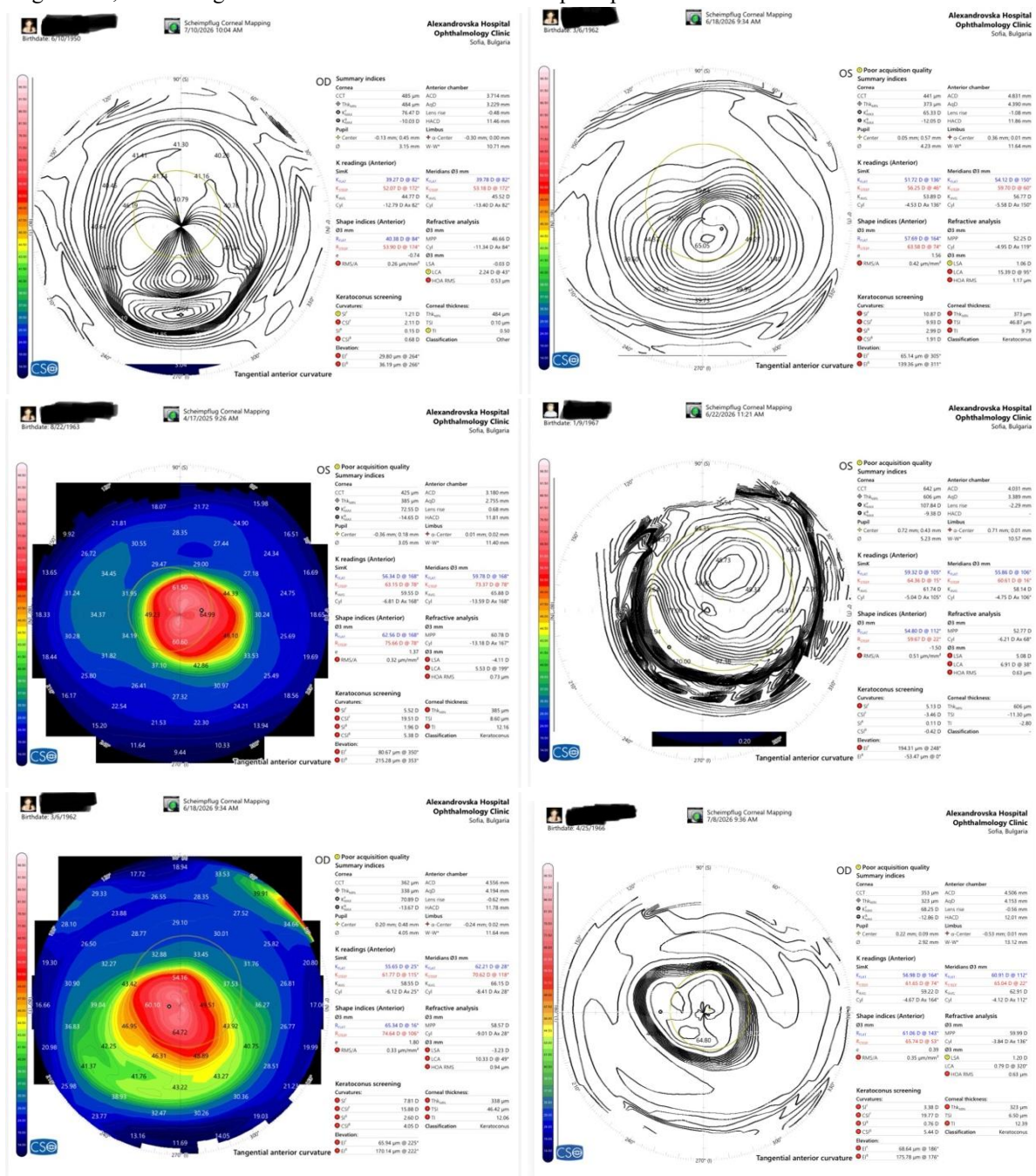


Figure No. 1: Corneal topography scans of all operated eyes.

All eyes underwent standard phacoemulsification through a clear corneal incision with in-the-bag implantation of the IC-8 intraocular lens. In all cases, the surgery went without intraoperative complication. In 4 patients (5 eyes) the implanted IC-8 IOL was +10.00 diopters (D) because of high myopia and astigmatism, as this is the lowest D of the IOL available to us.

Postoperative treatment was identical in all patients and consisted of topical antibiotic, corticosteroid, and non-steroid anti-inflammatory drops. Visual acuity was evaluated on the 30th postoperative day.

To determine corneal irregularity, we used the Belin 'ABCD' classification system, which is used to classify the corneal changes in keratoconus. [11-14]

The Belin ABCD progression display is a diagnostic software tool used on the OCULUS Pentacam to track and document changes in corneal ectatic diseases like keratoconus.

A (Anterior): Anterior radius of curvature measured within a 3 mm zone centered on the thinnest point.

B (Back/Posterior): Posterior radius of curvature measured within the same 3 mm zone.

C (Corneal Thickness): Minimal pachymetry (thinnest point thickness) rather than a central reading.

D (Distance Visual Acuity): Best-corrected distance visual acuity.

Table No. 1: Representing the Belin Classification of each patient, preoperative refraction, diopter of the implanted IOL and postoperative BCVA.

Patient	A	B	C	D	Refraction	IOL Diopter	Postoperative BCVA
Patient 1 (Right eye)	A4	B4	C3	0.1 (20/200)	-6.00/60ax	+10.00	0.3 (20/60)
Patient 1 (Left eye)	A4	B4	C3	0.2 (20/100)	-4.50/130ax	+10.00	0.3 (20/60)
Patient 2	A4	B4	C3	0.4 (20/50)	-2.00/-12.75/80	+22.00	0.5 (20/40)
Patient 3	A4	B4	C4	0.1 (20/200)	-5.00/-6.50/50ax	+10.00	0.4 (20/50)
Patient 4	A4	B4	C3	0.03 (6/200)	-10.00/-4.75/165	+10.00	0.2 (20/100)
Patient 5	A4	B4	C3	0.1 (20/200)	-6.00/90	+10.00	0.2 (20/100)

III. RESULTS

Implantation of a small-aperture IOL proved to be the correct choice for the patients in our study, as all of them achieved improvement in the visual acuity.

Determining the optimal optical correction preoperatively for BCVA assessment was challenging due to inconsistent refractometry readings because of the irregular corneal pathologies. It required extensive evaluation, considering the corneal topography of each patient.

The patients had no complications in the recovery period after surgery and all patients followed strictly the prescribed postsurgery treatment.

On the 30th postoperative day each patient underwent visual acuity testing. We report their VA with the optimal correction in Table 1. Some of the patients required high diopters of optical correction due to the limitation of the 10 D IOL power.

IV. DISCUSSION

Management of cataract in eyes with abnormal corneas remains challenging because irregular astigmatism and higher-order aberrations frequently limit postoperative visual quality and reduce refractive predictability. In such eyes, conventional monofocal intraocular lenses may not adequately compensate for optical distortion, whereas multifocal lenses may further degrade image quality due to reduced contrast sensitivity and increased photic phenomena. The present study demonstrates that implantation of the IC-8 small-aperture intraocular lens can provide meaningful visual rehabilitation in selected patients with irregular corneal pathology undergoing cataract surgery. [10]

In our series, all eyes achieved postoperative improvement in functional vision without significant intraoperative or postoperative complications. Despite the presence of irregular corneal optics, the pinhole mechanism of the IC-8 lens appeared to reduce the impact of peripheral aberrated light rays, thereby improving retinal image quality and increasing tolerance to residual refractive error. These findings support the theoretical optical advantage of small-aperture technology in eyes with corneal irregularity. [1,2,5,6]

The optical principle of the IC-8 lens has been extensively described in previous studies. By limiting unfocused peripheral light rays and preferentially transmitting central paraxial rays, the lens increases depth of focus while reducing the effect of higher-order aberrations. This mechanism may be particularly beneficial in eyes with keratoconus, post-keratoplasty irregularity, or post-refractive surgery ectasia, where visual impairment is frequently related not only to lower-order refractive error but also to irregular optical distortion. [1,3,4]

Our findings are consistent with those reported by Ang and Hooshmand et al., who demonstrated favorable visual outcomes and high patient satisfaction following implantation of the IC-8 IOL. [4,5] In the multicenter retrospective series by Hooshmand et al., the IC-8 lens provided extended depth of focus and good functional vision across multiple distances with relatively low incidence of disturbing photic phenomena. The authors also emphasized the forgiving refractive profile of the lens, particularly in eyes with residual refractive error. [5]

Importantly, several previous reports specifically evaluated the use of the IC-8 lens in eyes with irregular corneas. Several previous reports have specifically evaluated small-aperture IOL implantation in eyes with irregular corneal optics. Shajari et al. reported the safety and efficacy of capsular-bag fixation of the IC-8 IOL in eyes with severe corneal irregularities, demonstrating improvement in visual acuity and supporting the ability of small-aperture optics to reduce the visual impact of higher-order aberrations. [6] Langer et al. subsequently evaluated refractive predictability in eyes with highly irregular corneas and demonstrated postoperative improvement in visual acuity, while also highlighting the challenges of IOL power calculation in these eyes. [6,7] Our results are in agreement with these observations and further support the use of small-aperture technology in carefully selected patients with abnormal corneas. [7]

Franco et al. reported a retrospective series of 9 eyes in 6 patients with irregular corneas and higher-order aberrations. Their patients demonstrated improvement in BCVA and subjective visual function following IC-8 implantation. [8] These findings are relevant to our series because both studies involve highly irregular corneal optics in which conventional refractive correction may be insufficient.

More recently, Teo et al. evaluated visual outcomes in patients with aberrated corneas implanted with the IC-8 lens and similarly reported encouraging functional outcomes in this difficult patient population. [9] Collectively, these studies suggest that the IC-8 IOL may fill an important therapeutic gap between standard monofocal lenses and premium multifocal technologies in eyes with compromised corneal optics.

Collectively, these studies suggest that the IC-8 IOL may provide a useful optical strategy in selected cataract patients whose visual performance is limited by corneal irregularity. However, the available evidence remains based predominantly on case series and observational studies, and the optimal patient selection criteria remain incompletely defined. [10]

An important consideration in these patients is the balance between improved depth of focus and potential reduction in retinal illuminance due to the small-aperture design. Previous studies have evaluated contrast sensitivity and subjective visual symptoms following IC-8 implantation, with generally favorable results, although visual symptoms and photic phenomena may still occur in some patients. The recent study by Teo et al. also evaluated photic and mesopic contrast sensitivity and reported generally favorable binocular visual performance. [9] Careful patient counseling therefore remains essential, particularly in individuals with preexisting retinal pathology or patients with high visual demands in low-light conditions.

Another potential advantage of the IC-8 lens is its relative tolerance to residual refractive error and astigmatism. Achieving exact refractive targets in eyes with keratoconus or previous keratoplasty can be difficult because of irregular corneal measurements and reduced predictability of intraocular lens calculations. The increased depth of focus associated with the small-aperture design may partially compensate for these inaccuracies and contribute to improved postoperative satisfaction. [4,6,7]

The present study has several limitations. The sample size was small, reflecting the relatively uncommon indication and highly selected patient population. In addition, the retrospective design and short follow-up period limit evaluation of long-term refractive stability, posterior capsular opacification, and late visual quality outcomes. Quantitative assessment of contrast sensitivity and higher-order aberrations was not performed. Nevertheless, our study reflects real-world clinical experience and demonstrates the feasibility and potential value of IC-8 implantation in eyes with irregular corneal pathology.

V. CONCLUSION

In conclusion, the IC-8 small-aperture intraocular lens appears to be a promising option for cataract patients with abnormal corneas, particularly in cases of keratoconus and post-keratoplasty irregular astigmatism. The lens may improve functional vision by minimizing the effect of corneal aberrations while simultaneously increasing depth of focus. Larger prospective studies with longer follow-up are required to better define patient selection criteria, long-term outcomes, and visual quality parameters in this challenging patient population.

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