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Custom-made anterior chamber intraocular lens for aphakia: a case report

Omid Kermani[1*]

Abstract

Background Aphakia without adequate capsular support requires alternative intraocular lens (IOL) fixation strategies. Standard options include sulcus-fixated posterior chamber IOLs and retropupillary iris-claw lenses, both of which depend on specific anatomical prerequisites. When these are absent, anterior chamber IOLs (AC-IOLs) become one of the few remaining options; however, the only widely available angle-supported model has been the rigid Kelman Multiflex (PMMA), unchanged since its FDA approval in 1980. We describe the development and three-year clinical outcome of a custom-made, foldable, hydrophilic-acrylic, angle-supported AC-IOL implanted in an eye in which neither sulcus nor iris-claw fixation was feasible.

Case presentation A 21-year-old woman presented with right-eye aphakia following congenital cataract surgery in early childhood, with contact lens intolerance. Extensive posterior iris–capsule–vitreous synechiae and a maximum pupil diameter of 4.0 mm precluded both sulcus-fixated posterior chamber IOL and retropupillary iris-claw implantation. A custom foldable, three-haptic, angle-supported AC-IOL (VKL Type 37 F, Design Kermani; Morcher GmbH, Stuttgart, Germany) was designed under MDR Article 2(3) for custom-made devices and, after a development period, implanted at 24 years of age through a 2.6 mm incision under topical anaesthesia. Over 36 months, uncorrected distance visual acuity improved from 20/400 to 20/25 and corrected distance visual acuity reached 20/20. Intraocular pressure remained stable at 20 mmHg. Endothelial cell density decreased from 2927 to 2704 cells/mm^2 (– 7.6%). Scheimpflug imaging confirmed an IOL-to-endothelium distance of 1.68 mm and IOL rotation of less than 5°. No inflammation, pupillary distortion, or secondary glaucoma was observed.

Conclusions This custom-made, foldable, angle-supported AC-IOL demonstrated stable centration, refractive predictability, and acceptable endothelial cell loss over three years. It may offer a minimally invasive secondary IOL option for selected aphakic eyes in which sulcus or iris-claw fixation is not feasible, and may represent a contemporary alternative to the rigid PMMA designs that have dominated the angle-supported AC-IOL segment since 1980.

Keywords Anterior chamber intraocular lens, Custom IOL, Aphakia, Case report, Refractive outcome

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Background

Aphakia following cataract surgery remains a significant global challenge. In developing countries, the leading causes are traumatic lens loss and limited access to modern ophthalmic surgical care [1]. In developed nations, aphakia more commonly results from complicated cataract surgery with capsular loss — precluding posterior chamber intraocular lens (PC-IOL) implantation — or from late spontaneous dislocation of the entire IOL–capsular-bag-complex, typically occurring 10 to 20 years postoperatively and necessitating IOL exchange [2].

Current standard approaches include sulcus fixation of a PC-IOL and retropupillary fixation of an iris-claw lens [3]. Both techniques are technically demanding, time-consuming, and associated with notable complication rates [4].

In the patient presented here, neither approach was feasible due to her specific anatomical circumstances. We therefore developed a custom-made anterior chamber IOL (AC-IOL) tailored to her individual requirements. The implant was designed to be fabricated from a proven hydrophilic acrylic material, to be foldable, and to be injectable through an incision of no more than 2.6 mm using a standard cartridge injector.

We report on the design of this custom implant, the surgical technique, and the postoperative outcomes over a 3-year follow-up period.

Case presentation

Patient & history

A 21-year-old female presented with unilateral right-eye aphakia following presumed congenital cataract surgery in early childhood. No IOL had been implanted at that time, and contact lens correction had been used ever since. Regular ophthalmological follow-up was absent; systemic and ocular history was otherwise unremarkable.

Extensive posterior iris–capsule–vitreous synechiae precluded both sulcus-fixated posterior chamber IOL and retropupillary iris-claw implantation; after weighing the remaining alternatives, an angle-supported anterior chamber IOL was selected (see Discussion). Using the Cachet phakic AC-IOL (Alcon Laboratories) as a design reference [5], a custom foldable, hydrophilic-acrylic, angle-supported AC-IOL injectable through a ≤ 2.5 mm incision was commissioned. Following two years of development, the lens was implanted when the patient was 24 years of age.

Preoperative findings

Slit-lamp examination of the right eye showed superficial conjunctival injection and discrete superior corneal neovascularization consistent with prolonged contact lens wear; the cornea was clear and topographically unremarkable. The anterior chamber was deep and quiet.

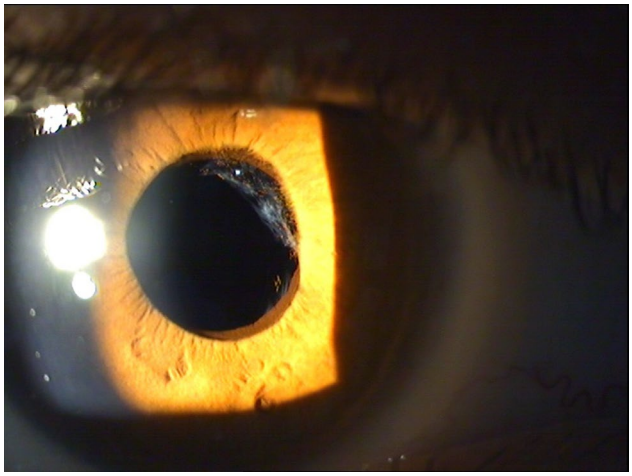

Fig. 1 Anterior segment photograph of the right eye prior to implantation. Maximal pharmacologic mydriasis was limited to 4.0 mm due to extensive posterior iris–capsule–vitreous synechiae. Note the atrophic iris stroma and sphincter

Table 1 Preoperative biometric and refractive findings

Parameter	Right Eye	Left Eye
UDVA	20/400	20/20
CDVA	20/25	20/16
Manifest refraction	+10.50 – 1.25 / 162°	–0.50 – 0.50 / 180°
IOP (mmHg)	20	16
Axial length (mm)	25.53	23.81
Corneal astigmatism	–1.86 / 156°	–0.79 / 4°
CCT (µm)	598	587
W2W (mm)	12.2	12.0
ACD (mm)	4.21	3.43

UDVA = Uncorrected distance visual acuity; CDVA = Corrected distance visual acuity; IOP = Intraocular pressure; CCT = Central corneal thickness; W2W = White-to-white; ACD = Anterior chamber depth. Refraction and corneal astigmatism in diopters (D)

Pharmacologic mydriasis was limited to 4.0 mm due to posterior iris–capsule–vitreous synechiae over several clock hours (Fig. 1).

Gonioscopy revealed a widely open angle with isolated peripheral anterior synechiae at the 6-o'clock position in the right eye; the left angle was normal. The optic disc and retina were unremarkable bilaterally. UBM was not available. Quantitative preoperative data are summarized in Table 1.

IOL specifications

The implanted lens was a custom-made, foldable, angle-supported anterior chamber IOL (VKL Type 37 F, Design Kermani; Morcher GmbH, Stuttgart, Germany), manufactured under Article 2(3) of the European Medical Device Regulation (Regulation [EU] 2017/745), which permits production of custom-made devices prescribed for an individual patient.

Specifications are summarized in Table 2. Three symmetrical, spirally arranged haptics with a 10° angulation

Table 2 Specifications of the custom-made anterior chamber intraocular lens

Parameter	Value
Model designation	VKL Type 37 F, Design Kermani
Manufacturer	Morcher GmbH, Stuttgart, Germany
Regulatory framework	Custom-made device per MDR (EU) 2017/745, Art. 2(3)
Material	Coacryl 28 (hydrophilic acrylic)
Water content	28%
Optic design	Spherical
Optic diameter	5.0 mm
Central optic thickness (at + 18.0 D)	0.7 mm
Haptic configuration	3 symmetrical, spirally arranged
Haptic angulation	10° anterior
Haptic width	0.5 mm
Haptic foot diameter	1.0 mm (rounded)
Overall diameter	13.0 mm
Implanted power	+ 13.0 D
Calculation	+ 18.0 D PC-IOL (A = 118.4, IOLMaster) – 4.0 D
Incision size	≤ 2.5 mm (cartridge injector)

The lens was manufactured as a custom-made device under Article 2(3) of the European Medical Device Regulation (EU) 2017/745. MDR = Medical Device Regulation; PC-IOL = Posterior chamber intraocular lens

Fig. 2 Photograph of the IOL prototype (VKL Type 37 F, Design Kermani; Morcher GmbH, Stuttgart, Germany) in top view. The 10° haptic angulation lifts the 5.0 mm optic anteriorly; three spirally arranged haptics with rounded feet (Ø 1.0 mm) extend to an overall diameter of 13.0 mm

maintain aqueous flow through the pupil and prevent pupillary block, obviating the need for a peripheral iridotomy – a concept adopted from the Cachet phakic ACIOL (Alcon Laboratories) [5]. The rounded haptic feet (1.0 mm diameter, exceeding the 0.5 mm haptic width) distribute the load on the chamber angle. Correct anterior–posterior orientation at implantation is essential to preserve clearance between the posterior optic surface and the pupillary plane (Fig. 2).

For this patient, an IOL power of + 13.0 D was selected, corresponding to a calculated + 18.0 D posterior chamber IOL (A-constant 118.4, IOLMaster) minus + 4.0 D to account for the more anterior plane of fixation.

Lens sizing followed the principle established for angle-supported and ciliary-sulcus-fixated phakic IOLs, for which the horizontal white-to-white (W2W) corneal diameter is the manufacturer-accepted reference for length selection. For a W2W of 12.1 mm, an overall diameter of 13.0 mm was chosen, providing an approximately 0.9 mm allowance for adequate—but not excessive—haptic tension within the angle. An undersized implant risks insufficient angle apposition with consequent rotation, decentration, and pseudophacodonesis, whereas an oversized implant risks excessive angle compression, pupil ovalisation, chronic irritation, and pressure on the angle structures. The flexible three-haptic design tolerates a modest range of angle dimensions and accommodates the physiological difference between the horizontal W2W and the slightly larger internal angle-to-angle diameter.

Surgical technique

The pupil was constricted with two instillations of pilocarpine 1% eye drops administered 30 and 15 min prior to surgery. Topical anaesthesia was achieved with oxybuprocaine hydrochloride eye drops (Conjuncain, Germany). Asepsis was performed with povidone-iodine 4%.

A perilimbal incision (PLI) of 2.6 mm was created temporally, with two paracenteses (1.0 mm each) placed 60° on either side of the main incision. The anterior chamber was filled with viscoelastic (ProVisc, Alcon Laboratories, Fort Worth, TX, USA). The IOL was loaded into a Monarch III C injector (Alcon Laboratories) and implanted through the PLI. Clockwise orientation of the haptics confirmed correct implantation, ensuring aqueous flow through the pupil and eliminating the need for a peripheral iridotomy. The haptics self-positioned within the chamber angle without further manipulation. The viscoelastic was removed by bimanual irrigation/aspiration and the incisions were sealed by stromal hydration with balanced salt solution (BSS). Postoperatively, a dexamethasone/neomycin/polymyxin B ophthalmic ointment (Isopto-Max, Cranach-Pharma GmbH, Hamburg, Germany) was applied.

Postoperative course

The postoperative course was uneventful. On day 1, uncorrected visual acuity (UCVA) was 20/25 with an intraocular pressure of 20 mmHg; only minimal conjunctival injection was noted. Examinations at one week and

one month were unchanged and unremarkable. The manifest refraction showed minor fluctuations throughout the early postoperative period, but the spherical equivalent (SEQ) remained below 1.0 D at all visits.

Scheduled follow-up examinations were performed at 12, 24, and 36 months. Endothelial cell density (ECD), measured with a specular microscope (CEM-530, Nidek Co., Gamagori, Japan), was 2852 cells/mm² at 12 months, 2732 cells/mm² at 24 months, and 2704 cells/mm² at 36 months, representing a total loss of 7.6% from the preoperative value of 2927 cells/mm² (Fig. 3a–d). At the 36-month visit, UCVA was 20/25 and CDVA was 20/20 with a manifest refraction of $-0.50/-1.25\times178°$. IOP remained stable at 20 mmHg. Optical coherence tomography of the optic nerve head was normal. Scheimpflug imaging (Pentacam) demonstrated the IOL in cross-section, with a measured distance of 1.68 mm between the anterior IOL surface and the corneal endothelium (Fig. 4). Analysis of anterior segment photographs confirmed IOL rotation of less than 5° (Fig. 5).

Discussion and conclusions

In the patient presented here, the standard approaches for secondary IOL implantation in an aphakic eye were not feasible. Extensive posterior iris–capsule–vitreous synechiae precluded both sulcus fixation of a posterior chamber IOL and retropupillary fixation of an iris-claw lens, which requires adequate iris tissue and a mechanically engageable iris. Scleral fixation of a posterior chamber IOL — whether sutured or sutureless, such as flanged intrascleral or trans-scleral plug techniques — was technically feasible and would have offered the endothelial advantage of a posterior fixation plane. It was, however, considered less desirable rather than impossible in this individual patient. The decisive considerations were her young age, which would expose a scleral fixation to several decades of potential suture or haptic degradation, late tilt, or dislocation; the substantially greater intraocular and surgical trauma of a transscleral procedure compared with sutureless anterior chamber implantation; and the correspondingly longer operating time and rehabilitation. Weighing these trade-offs against a comparatively straightforward, sutureless angle-supported approach, an anterior chamber IOL was selected, while acknowledging that the principal long-term uncertainty of this choice is endothelial cell loss (see below).

The only commercially available anterior chamber IOL at the time — the Kelman Multiflex (PMMA, FDA-approved 1980) — is rigid, requires a large incision, and carries a well-documented complication profile including uveitis-glaucoma-hyphema (UGH) syndrome [4]. A foldable, injectable, angle-supported AC-IOL made from a biocompatible hydrophilic acrylic therefore appeared to be a suitable solution in this individual case.

The custom implant drew on the Cachet phakic AC-IOL (Alcon Laboratories) in two respects: the concept of a foldable, injectable design permitting implantation through a small incision, and the principle of anteriorly angulated haptics that maintain aqueous flow through the pupil, eliminating the need for a peripheral iridotomy. Several deliberate departures were made: hydrophilic acrylic (Coacryl 28, Morcher GmbH), a widely used and well-tolerated intraocular biomaterial, was selected instead of the hydrophobic material of the Cachet. Haptic stiffness was increased to ensure adequate angle compression, and the number of support points was reduced from four to three — the minimum for stable self-centering — simplifying implantation while maintaining rotational stability [6].

The overall AC-IOL diameter of 13.0 mm (W2W 12.1 mm) ensures sufficient haptic tension, preventing pseudophacodonesis and rotational displacement. A key biomechanical feature is anterior optic displacement under haptic compression, analogous to a spring mechanism. Laboratory measurements confirmed a maximum displacement of 1.5 mm. Given the deep anterior chamber of the aphakic eye, this does not compromise endothelial safety, as confirmed by the IOL-to-endothelium distance of 1.68 mm at 36 months.

At three years, the results demonstrate stable visual rehabilitation and good ocular tolerability. UCVA of 20/25 and CDVA of 20/20 represent a substantial improvement from the preoperative UCVA of 20/400. IOP remained stable with no signs of angle compromise or secondary glaucoma.

Endothelial cell density declined from 2927 cells/mm² preoperatively to 2852, 2732, and 2704 cells/mm² at 12, 24, and 36 months, representing cumulative losses of 2.6%, 6.7%, and 7.6%, respectively (Fig. 3a–d). The majority of cell loss occurred within the first year, likely attributable to surgical trauma rather than chronic IOL-related stress [7]. The reduced loss between 24 and 36 months (0.7%) suggests a tendency toward stabilization after the first postoperative year; a three-year follow-up cannot, however, establish long-term endothelial safety. Because the patient is young, the corneal endothelium must remain functional for many decades, and an angle-supported AC-IOL carries an inherent, cumulative endothelial risk that only continued annual specular-microscopy monitoring can adequately assess. The present data should therefore be interpreted as indicating encouraging short- to medium-term tolerability rather than as evidence of long-term safety. The IOL-to-endothelium distance of 1.68 mm is relatively narrow but, in this deep aphakic anterior chamber, compatible with good clinical tolerability to date. The anterior optic displacement results from both the haptic angulation and haptic compression, raising the question of whether a reduced

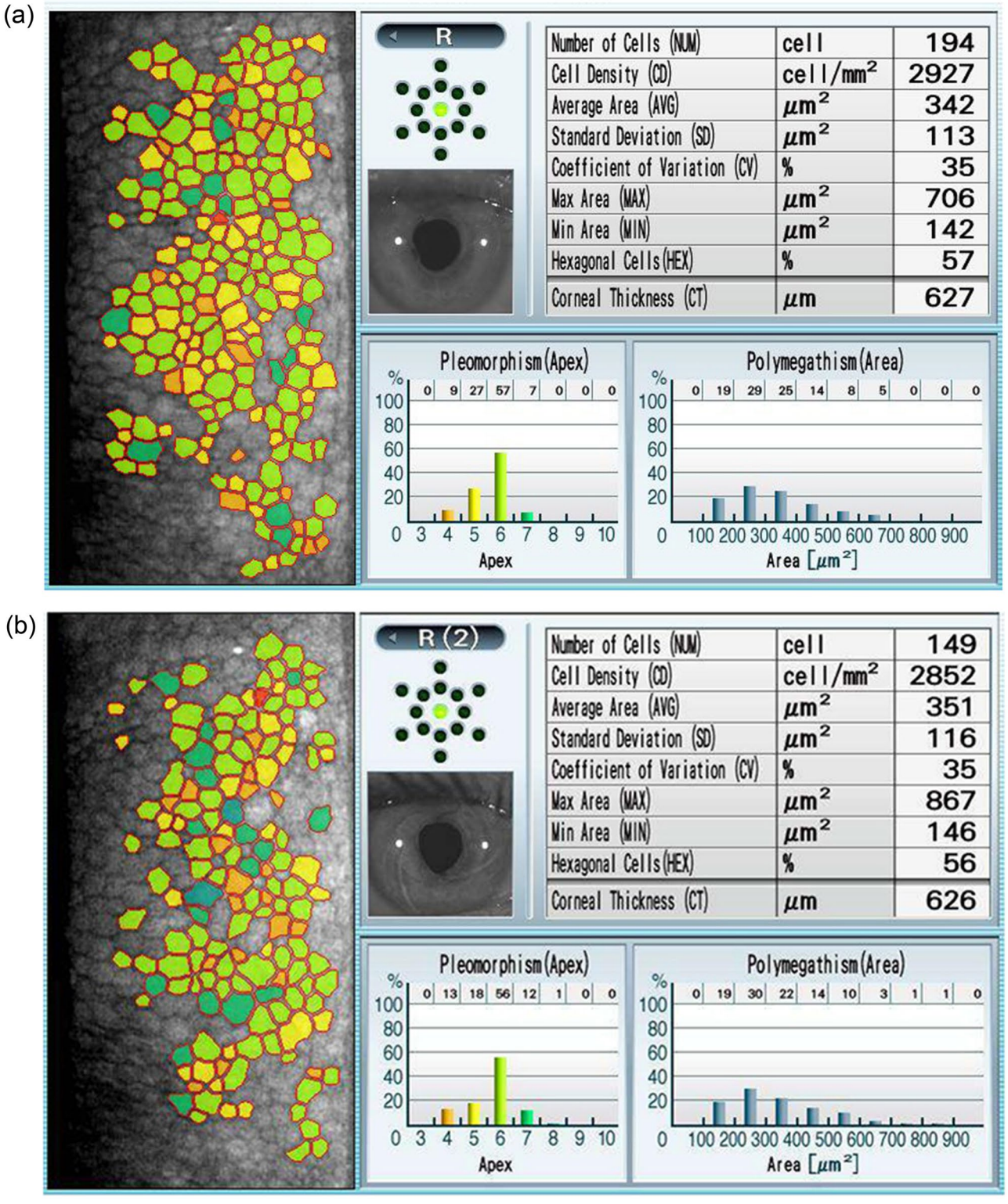

Fig. 3 Specular microscopy (CEM-530, Nidek) of the central corneal endothelium at four time points: (**a**) preoperatively, (**b**) 12 months, (**c**) 24 months, and (**d**) 36 months postoperatively. Endothelial cell density values are reported in the main text

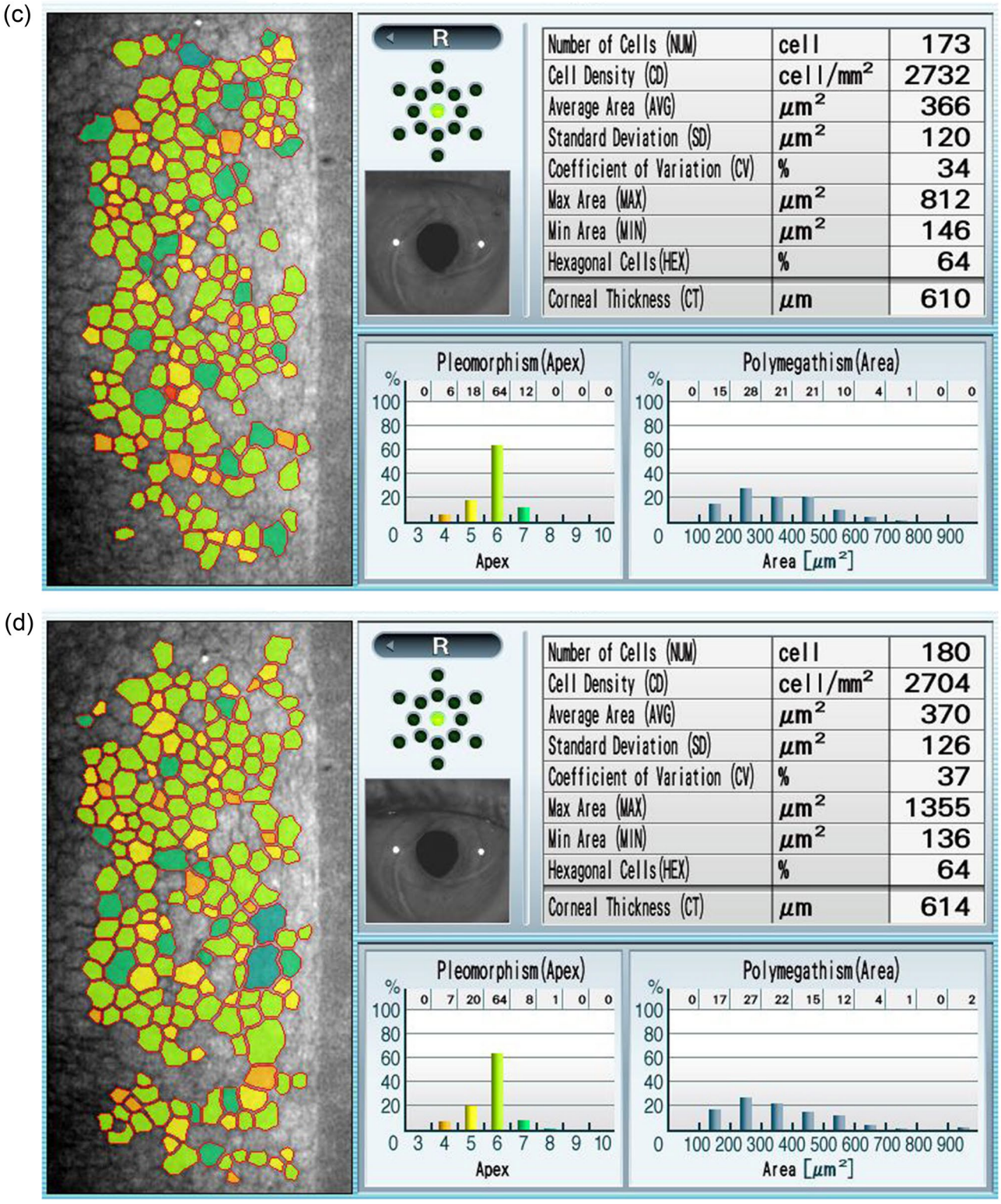

Fig. 3 (continued)

angulation in future iterations might increase the endothelial safety margin — a parameter warranting further laboratory modelling.

Sulcus-fixated PC-IOLs, retropupillary iris-claw lenses, and scleral fixation techniques each carry limitations that made them less suitable in this particular case [3,

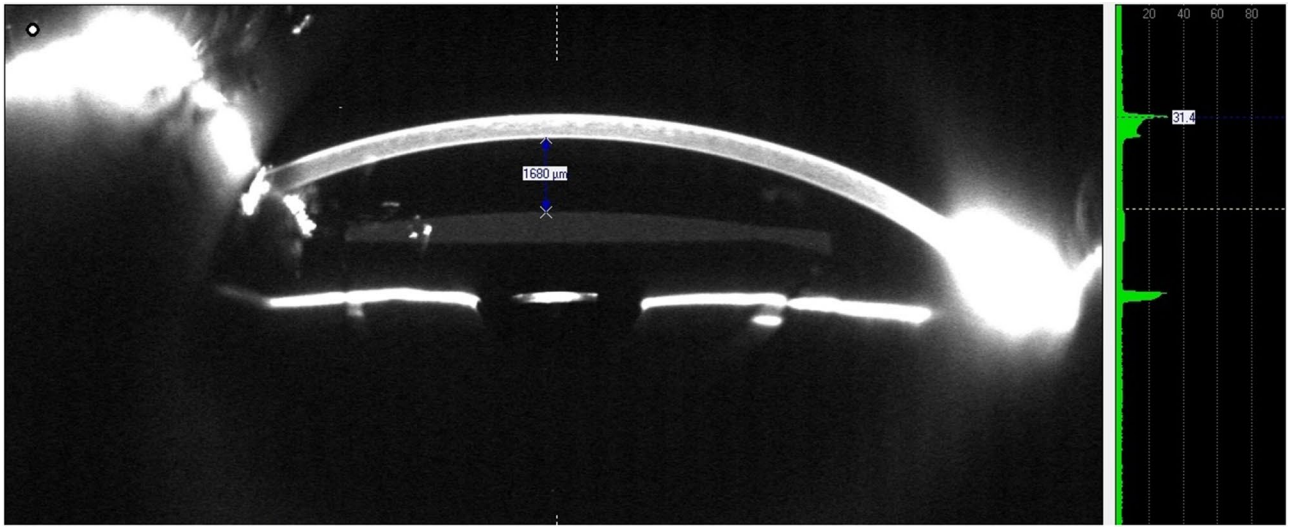

Fig. 4 Scheimpflug cross-section (Pentacam) of the custom-made AC-IOL in the anterior chamber. The distance between the anterior IOL surface and the corneal endothelium measures 1.68 mm

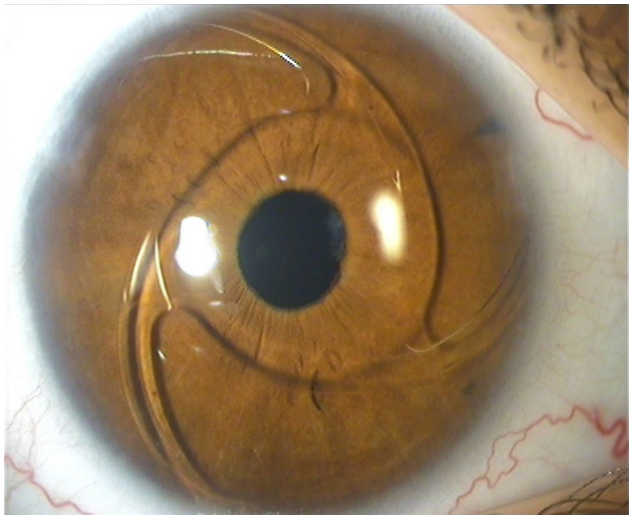

Fig. 5 Anterior segment photograph at 36 months postoperatively. The IOL is well centered and stable in the chamber angle, with a confirmed rotation of less than 5° from the implanted axis

8–10]. While posterior chamber fixation methods offer long-term endothelial advantages through greater IOL-to-endothelium distance, they are technically demanding, time-consuming, and associated with substantially greater intraocular trauma. The initial endothelial cell loss following these procedures is likely considerably higher than observed in the present case. The custom AC-IOL, by contrast, was injected through a ≤ 2.6 mm incision under topical anaesthesia, with haptics self-positioning in the chamber angle without sutures or vitreoretinal instrumentation, completing the procedure within minutes. Anterior chamber IOLs have historically been associated with UGH syndrome, corneal decompensation, and glaucoma — complications largely attributable to rigid PMMA designs [4]. The present implant may represent a contemporary alternative combining the procedural simplicity of anterior chamber implantation with modern material biocompatibility. To our knowledge, no comparable foldable, injectable, angle-supported AC-IOL is currently commercially available.

This report is limited by its single-case design and a three-year follow-up that does not yet permit conclusions about decade-long endothelial safety; lens sizing relied on white-to-white measurement rather than ultrasound biomicroscopy, consistent with current practice for angle-supported and ciliary-sulcus-fixated phakic IOLs. Larger controlled studies with longer follow-up are needed.

In conclusion, this custom-made foldable AC-IOL demonstrated stable visual rehabilitation, good angle tolerability, and acceptable endothelial cell loss over three years in an eye in which standard secondary IOL techniques were not considered suitable. In this selected case, its minimal invasiveness and procedural simplicity may offer practical advantages, and the approach warrants further clinical investigation with longer follow-up.

Abbreviations

AC-IOL	Anterior chamber intraocular lens
ACD	Anterior chamber depth
CCT	Central corneal thickness
CDVA	Corrected distance visual acuity
ECD	Endothelial cell density
IOL	Intraocular lens
IOP	Intraocular pressure
MDR	Medical Device Regulation
PC-IOL	Posterior chamber intraocular lens
PMMA	Poly(methyl methacrylate)
UDVA	Uncorrected distance visual acuity
UGH	Uveitis–glaucoma–hyphema (syndrome)
W2W	White-to-white

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Author contributions
The manuscript was completed using the Claude® artificial intelligence platform.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This case report was conducted in accordance with the Declaration of Helsinki. The custom-made intraocular lens was manufactured under Article 2(3) of the European Medical Device Regulation (Regulation [EU] 2017/745), which permits the production of custom-made devices prescribed for an individual patient by an authorized healthcare professional. No institutional ethics committee approval is required for a single-patient case report at the author's institution. Written informed consent for participation was obtained from the patient prior to the procedure.

Consent for publication
Written informed consent for the publication of clinical details and accompanying images was obtained from the patient. A copy of the consent form is available on request to the Editor.

Competing interests
The author is inventor and potentially receives royalties for the product.

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