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Research Article

Anterior segment angle changes, vault, and intraocular pressure after phakic intraocular lens implantation: An anterior segment optical coherence tomography study

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ABSTRACT

Objective: This study aimed to evaluate 6-month changes in iridocorneal angle morphology, central vault, and intraocular pressure after toric phakic intraocular lens implantation, using anterior segment optical coherence tomography.

Methods: This retrospective single-surgeon cohort included 21 right eyes of 21 patients who completed 1- and 6-month follow-up after toric phakic intraocular lens implantation. Angle opening distance and trabecular–iris space area at 500 and 750 μm , and trabecular–iris angle, were measured nasally and temporally. Anterior chamber depth, anterior chamber width, vault, intraocular pressure, and spherical equivalent were also recorded.

Results: Spherical equivalent improved from -8.06 ± 2.43 D to -0.32 ± 0.32 D at 6 months ($p < 0.001$). Vault was 578 ± 89 μm at 1 month and 559 ± 81 μm at 6 months ($p = 0.006$); all eyes remained within 250–750 μm . Trabecular–iris angle decreased by 42.3%, and angle opening distance and trabecular–iris space area by 52–59% (all $p < 0.001$), with no further narrowing after month 1. Intraocular pressure was 14.5 ± 2.4 , 20.9 ± 3.7 , and 17.8 ± 3.3 mmHg at the three visits. Six-month vault correlated with preoperative anterior chamber width ($r = 0.47$; $p = 0.030$) and axial length ($r = 0.44$; $p = 0.046$).

Conclusion: Toric phakic intraocular lens implantation was associated with early angle narrowing followed by stabilization through month 6. Vault remained within 250–750 μm . Associations between postoperative vault, anterior chamber width, and axial length were exploratory.

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1. Introduction

Myopia is a refractive error whose prevalence is rising rapidly worldwide; by 2050, it is projected to affect approximately half of the global population, with a substantial increase in the prevalence of high myopia [1]. Posterior chamber phakic intraocular lenses (pIOLs) provide a reversible surgical option for correcting myopia, astigmatism, and hyperopia, particularly in patients who are unsuitable for corneal refractive surgery because of thin corneas, irregular corneal topography, dry

eye, or other corneal or refractive considerations [2].

The most widely used platform in this field is the implantable collamer lens (ICL; STAAR Surgical). Nonetheless, a growing body of clinical evidence has accumulated for the Eyecryl Phakic IOL (Biotech Vision Care, Ahmedabad, India), a hydrophilic acrylic, plate-haptic, injectable posterior chamber pIOL. Yaşa and colleagues reported that Eyecryl was effective and safe at 12 months in high myopia, with a mean endothelial cell loss of 3.9% [3]. Kirgiz et al. and Çakır et al. demonstrated refractive stability and acceptable cumulative endothelial loss at 7

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and 5 years, respectively [4,5]. Ürdem and Ağca described successful refractive outcomes and limited endothelial loss at 2 years [6]. In a 2-year comparative study of toric models, Eyecryl yielded efficacy and safety indices similar to those of the Visian toric ICL [7].

Seating of a pIOL in the ciliary sulcus displaces the iris root anteriorly and thereby narrows the iridocorneal angle. Quantitative angle metrics—including angle opening distance (AOD), trabecular–iris space area (TISA), and trabecular–iris angle (TIA)—were first defined on anterior segment OCT by Radhakrishnan and co-workers and validated as a reproducible, non-contact alternative to gonioscopy and ultrasound biomicroscopy [8]. Using Fourier-domain OCT after ICL V4c implantation, Fernández-Vigo et al. documented reductions of approximately 34–42% in TIA and 50–58% in AOD500, with stability from month 1 through 2 years [9,10]; 10-year follow-up from the same group confirmed the absence of progressive long-term narrowing [11]. These observations have been reiterated in a recent review of the clinical role of AS-OCT in the surveillance of phakic and secondary intraocular lenses [12]. Series of IPCL and ICL implants likewise show that AOD and TISA fall at 1 month and remain unchanged thereafter [13–15]; the magnitude of angle narrowing has been related to preoperative anterior chamber depth (ACD) and postoperative vault [14,15].

Vault is defined as the distance between the posterior surface of the pIOL and the anterior surface of the crystalline lens and is a principal marker of postoperative safety. The widely accepted target range is 250–750 μm : values below this interval increase the risk of cataract, whereas higher values may predispose to angle closure and pigment dispersion [16]. Vault height is therefore relevant to anterior segment anatomy and iridocorneal angle morphology after pIOL implantation. Prior Pentacam and AS-OCT studies have examined associations between vault and anterior chamber or angle parameters [17,18], and a relationship between vault and the iridocorneal angle has also been demonstrated [19].

Although long-term vault and endothelial data exist for Eyecryl, nasal–temporal quantification of AOD500/750, TISA500/750, and TIA remains limited for this lens. The present study therefore examined the 6-month course of anterior segment parameters, angle morphology, vault, and IOP after Eyecryl implantation, using a single-surgeon design, a single technician, and only high-quality Optopol REVO FC scans.

2. Methods

2.1. Study design and patients

This was a retrospective observational cohort study. Medical records of patients who underwent toric Biotech Eyecryl posterior chamber phakic intraocular lens implantation between October 1, 2024, and September 1, 2026, were retrospectively reviewed. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Samsun University Non-Interventional Clinical Research Ethics Committee (approval no. 2026/16/24; approval date: September 2,

2026). Because of the retrospective nature of the study, the requirement for informed consent was waived by the ethics committee.

All patients underwent routine preoperative assessment for phakic IOL implantation. In general, phakic IOL implantation was considered in young patients with myopia and/or myopic astigmatism who were not considered suitable candidates for corneal refractive surgery because of corneal thickness, corneal characteristics, or refractive considerations. Patients with conditions precluding phakic IOL implantation, including clinically significant cataract, glaucoma, uveitis, or previous intraocular surgery, were not considered eligible for implantation.

During the study period, 23 consecutive patients who had undergone Eyecryl phakic IOL implantation were screened for eligibility. Two patients were excluded from the analysis because of incomplete postoperative follow-up. The remaining 21 patients fulfilled the study criteria and were included in the final analysis; one eye per patient (the right eye) was analysed.

2.2. Surgery

All procedures were performed by the same surgeon under standard topical anaesthesia through a 2.8-mm clear corneal incision. The lens was placed in the sulcus. The overall lens diameter was selected using the white-to-white (WTW) diameter obtained by optical biometry, while lens power was determined using the manufacturer's calculator based on the preoperative biometric and refractive parameters and the target refraction. Anterior chamber width measured on AS-OCT represented the angle-to-angle distance and was analyzed as an anatomical outcome rather than as an input for lens sizing. Peripheral iridectomy was not performed routinely, because the central 360- μm hole is designed to permit aqueous flow. Postoperatively, a topical moxifloxacin/dexamethasone fixed-combination preparation was administered five times daily during the first postoperative week, followed by topical dexamethasone four times daily for an additional 3 weeks and then discontinued.

2.3. Imaging protocol

All measurements were obtained with the Optopol REVO FC spectral-domain OCT (Optopol Technology, Zawiercie, Poland) by the same experienced technician, without an additional anterior segment adaptor. Examinations were performed with the patient in a seated position under standard clinical room-lighting conditions, without pharmacological pupillary dilation, while the patient fixated on the instrument's internal fixation target. The same acquisition conditions were maintained for all examinations. The device provides built-in software for AOD 500/750, TISA 500/750, angle assessment, and angle-to-angle imaging; definitions follow the method of Radhakrishnan et al. [8]. Only scans with a high signal-to-noise ratio and a clearly identifiable scleral spur were accepted.

Anterior chamber width (AWD) was defined as the angle-to-angle distance measured by AS-OCT and was evaluated as an anatomical parameter; it was not used as

an input for phakic IOL sizing. Central vault was measured in micrometres as the perpendicular distance between the posterior pIOL surface and the anterior capsule of the crystalline lens. ACD was measured from the corneal endothelium. Angle parameters were recorded separately as temporal (T) and nasal (N) measurements in the horizontal meridian:

AOD500 / AOD750: distance from the iris to a line perpendicular to the corneal endothelium 500 and 750

μm anterior to the scleral spur (mm). TISA500 / TISA750: area bounded by the scleral spur, the AOD line, the corneal endothelium, and the anterior iris surface (mm^2). TIA: trabecular meshwork–iris angle (degrees). IOP was measured by Goldmann applanation tonometry and recorded in mmHg. Representative Optopol REVO FC sections illustrating the measurement method are shown in Fig. 1 (vault, ACD, AWD) and Fig. 2 (AOD, TISA, TIA).

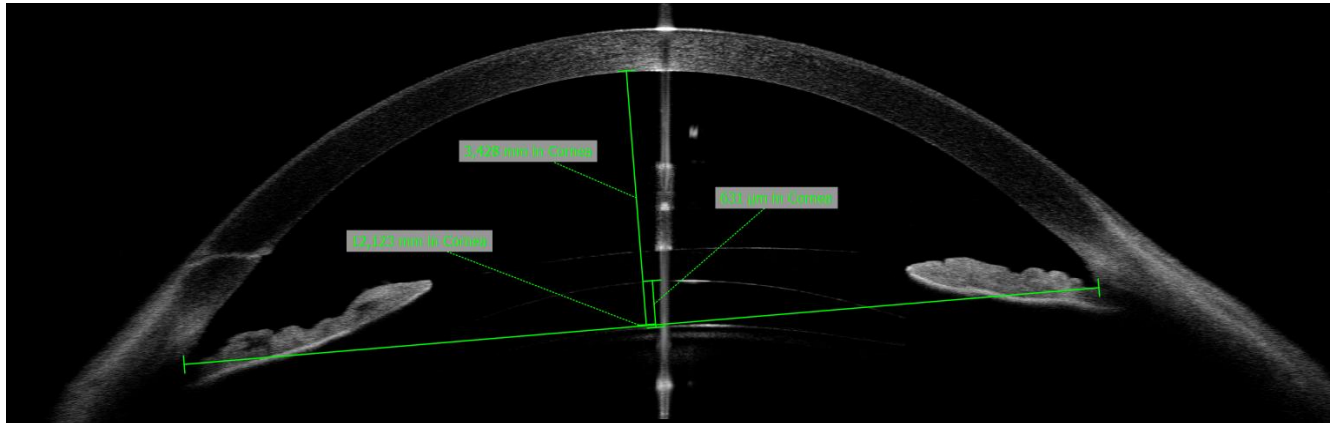


Fig. 1. Postoperative horizontal anterior segment OCT scan showing measurement of central vault, anterior chamber depth, and angle-to-angle distance (Optopol REVO FC). The vertical green caliper measures ACD from the endothelium to the anterior capsule of the crystalline lens (3.428 mm in this section); the short vertical caliper between the posterior lens surface and the anterior capsule indicates central vault (631 μm); the horizontal caliper denotes iridocorneal angle-to-angle distance / AWD (12.123 mm). The pIOL appears as a thin hyper-reflective plate. Patient identity has been concealed.

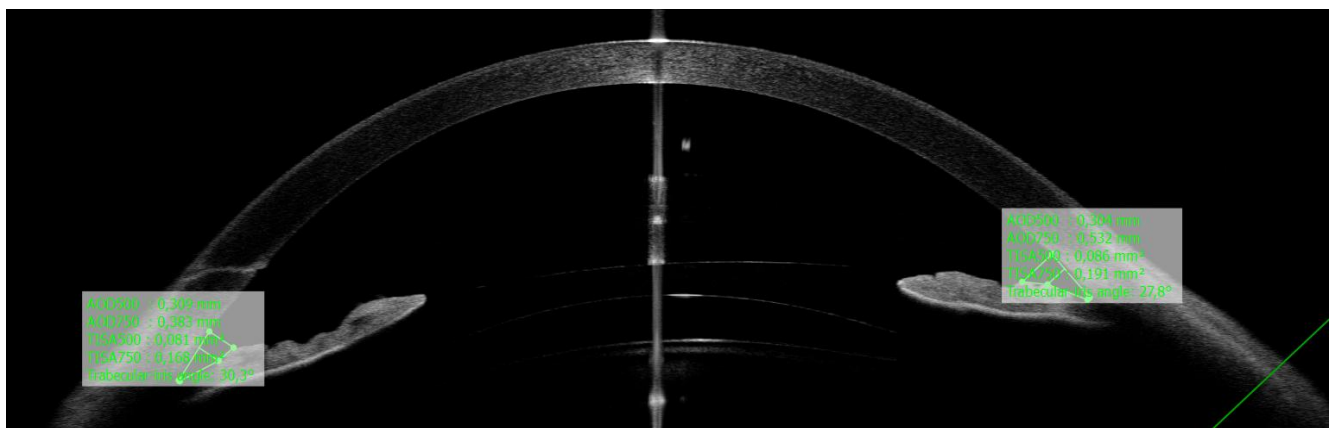


Fig. 2. Postoperative horizontal anterior segment OCT scan (Optopol REVO FC). After the scleral spur is marked, the software automatically calculates AOD500, AOD750, TISA500, TISA750, and trabecular–iris angle (TIA) in the temporal (left box) and nasal (right box) quadrants. In this section, temporal TIA is 30.3° and nasal TIA is 27.8°; AOD500 values are 0.309 mm and 0.304 mm, respectively. Green lines indicate AOD vectors and the TISA polygon. Patient identity has been concealed.

2.4. Statistics

Continuous variables are presented as mean $\pm$ standard deviation (range). The three time points (preoperative, month 1, and month 6) were compared using repeated-measures ANOVA. The Greenhouse–Geisser correction was applied when the assumption of sphericity was violated. The reported overall p value refers to the corrected repeated-measures ANOVA when applicable. When the overall test was significant, three pairwise comparisons were performed with Bonferroni adjust-

ment, with an adjusted significance threshold of $\alpha = 0.017$. The Friedman test was additionally used as a non-parametric, distribution-robust confirmation of the repeated-measures analysis. Because vault was measured only at the two postoperative visits, a single paired t -test was applied. Associations between the 6-month postoperative vault and ACD, AWD, axial length, and angle parameters were assessed using Pearson correlation. Two-sided $p < 0.05$ was considered statistically significant. Because only one eye per patient was included, eyes constituted statistically independent units.

3. Results

3.1. Demographics and refractive outcomes

Twenty-three consecutive patients were screened during the study period. Two patients were excluded because of incomplete postoperative follow-up, leaving 21 patients (21 right eyes) for the final analysis. All 21 included patients completed both the 1- and 6-month follow-up examinations. The patients included 12 women

and 9 men, with a mean age of 25.0 ± 4.2 years (range, 19–35). Preoperative axial length was 26.58 ± 1.35 mm (range, 23.65–28.30). Preoperative sphere was -6.68 ± 2.95 D, cylinder -2.76 ± 1.36 D, and spherical equivalent -8.06 ± 2.43 D (range, -11.63 to -2.63). At 6 months, spherical equivalent was -0.32 ± 0.32 D (RM-ANOVA $p < 0.001$; Bonferroni-adjusted preoperative vs. 6-month $p < 0.001$; month 1 vs. month 6 adjusted $p = 1.00$). At 6 months, 85.7% of eyes were within ± 0.50 D and 100% were within ± 1.00 D (Table 1).

Table 1. Demographic and refractive data ($n = 21$ patients / 21 right eyes).

Parameter	Preoperative	Month 1	Month 6
Sphere (D)	-6.68 ± 2.95	-0.19 ± 0.33	-0.10 ± 0.35
Cylinder (D)	-2.76 ± 1.36	-0.36 ± 0.37	-0.45 ± 0.33
Spherical equivalent (D)	-8.06 ± 2.43	-0.37 ± 0.33	-0.32 ± 0.32
Within ± 0.50 D (%)	—	—	85.7
Within ± 1.00 D (%)	—	—	100
Axial length (mm)	26.58 ± 1.35	—	—

3.2. Vault

Central vault measured 578 ± 89 μ m (416–682) at 1 month and 559 ± 81 μ m (404–700) at 6 months. The difference was statistically significant but clinically small (mean -19 μ m; paired t -test $p = 0.006$; no multiple-comparison correction was required because only two time points were available). At both visits every eye lay within the 250–750 μ m interval; no vault below 250 μ m or above 750 μ m was observed. The 6-month postoperative vault correlated positively with preoperative AWD ($r = 0.47$; $p = 0.030$) and axial length ($r = 0.44$; $p = 0.046$). The association with preoperative ACD was not significant ($r = 0.30$; $p = 0.19$). Vault was not significantly correlated with 6-month TIA, AOD750, or TISA750. A representative 6-month section is shown in Fig. 1.

3.3. Anterior chamber depth and width

ACD was 3.525 ± 0.088 mm preoperatively, 3.449 ± 0.161 mm at 1 month, and 3.449 ± 0.162 mm at 6 months. The overall repeated-measures ANOVA was significant ($p = 0.001$); after Greenhouse–Geisser correction, the overall p value was 0.010. However, the Bonfer-

roni-adjusted preoperative versus 6-month comparison was not statistically significant ($p = 0.030$, adjusted $\alpha = 0.017$), and there was no difference between months 1 and 6 (adjusted $p = 1.00$). The absolute reduction of 0.08 mm was clinically limited.

AWD decreased from 11.855 ± 0.347 mm preoperatively to 11.763 ± 0.378 mm at 1 month and 11.726 ± 0.362 mm at 6 months (Bonferroni-adjusted preoperative vs. 6-month $p < 0.001$).

3.4. Iridocorneal angle parameters

Parallel narrowing was observed in the nasal and temporal quadrants (Tables 2 and 3). Mean $((T+N)/2)$ TIA fell from $52.65 \pm 5.15^\circ$ to $30.61 \pm 3.47^\circ$ at 1 month and $30.38 \pm 3.64^\circ$ at 6 months (-42.3% ; RM-ANOVA $p < 0.001$; Bonferroni preoperative vs 6 months $p < 0.001$). AOD500, AOD750, TISA500, and TISA750 decreased by 52.3%, 52.7%, 59.3%, and 59.0%, respectively (RM-ANOVA and Bonferroni preoperative vs 6 months $p < 0.001$ for all). No angle parameter changed significantly between months 1 and 6 (Bonferroni-adjusted $p = 0.33$ – 1.00). Quadrant asymmetry was not marked. A representative postoperative angle measurement is shown in Fig. 2.

Table 2. Angle opening distance (AOD) and trabecular–iris space area (TISA).

Parameter	Preoperative	Month 1	Month 6	$\Delta\%$ (pre–6 mo)
AOD500-T (mm)	0.835 ± 0.277	0.406 ± 0.111	0.397 ± 0.119	-52.5^*
AOD500-N (mm)	0.850 ± 0.248	0.410 ± 0.110	0.408 ± 0.112	-52.1^*
AOD750-T (mm)	1.540 ± 0.389	0.742 ± 0.255	0.730 ± 0.270	-52.6^*
AOD750-N (mm)	1.591 ± 0.307	0.750 ± 0.266	0.751 ± 0.263	-52.8^*
TISA500-T (mm ²)	0.246 ± 0.080	0.104 ± 0.021	0.102 ± 0.025	-58.3^*
TISA500-N (mm ²)	0.247 ± 0.075	0.102 ± 0.024	0.098 ± 0.022	-60.2^*
TISA750-T (mm ²)	0.531 ± 0.147	0.223 ± 0.052	0.218 ± 0.058	-59.0^*
TISA750-N (mm ²)	0.543 ± 0.129	0.226 ± 0.060	0.223 ± 0.061	-58.9^*

* After RM-ANOVA, Bonferroni-adjusted preoperative vs 6-month $p < 0.001$. Differences between months 1 and 6 were not significant (adjusted $p > 0.05$).

Table 3. Trabecular–iris angle, ACD, AWD, vault, and intraocular pressure.

Parameter	Preoperative	Month 1	Month 6	<i>p</i> *
TIA-T (°)	52.2 ± 5.6	30.7 ± 3.4	30.4 ± 4.2	<0.001
TIA-N (°)	53.1 ± 5.1	30.5 ± 3.8	30.4 ± 3.6	<0.001
Mean TIA (°)	52.7 ± 5.1	30.6 ± 3.5	30.4 ± 3.6	<0.001
ACD (mm)	3.525 ± 0.088	3.449 ± 0.161	3.449 ± 0.162	0.030
AWD (mm)	11.855 ± 0.347	11.763 ± 0.378	11.726 ± 0.362	<0.001
Vault (μm)	—	578 ± 89	559 ± 81	0.006†
IOP (mmHg)	14.5 ± 2.4	20.9 ± 3.7	17.8 ± 3.3	<0.001

* For angle, ACD, AWD, and IOP, the *p* column reports the Bonferroni-adjusted preoperative versus 6-month pairwise *p* value following the repeated-measures ANOVA. The adjusted significance threshold for pairwise comparisons was $\alpha = 0.017$. For ACD, the Greenhouse–Geisser-corrected overall *p* value was 0.010, whereas the Bonferroni-adjusted preoperative versus 6-month pairwise *p* value was 0.030. † Vault was measured only at months 1 and 6 and was compared using a paired *t*-test. IOP, intraocular pressure.

3.5. Intraocular pressure

IOP was 14.5 ± 2.4 mmHg (11–20) preoperatively, 20.9 ± 3.7 mmHg (14–28) at 1 month, and 17.8 ± 3.3 mmHg (12–23) at 6 months. RM-ANOVA for IOP was significant ($F = 49.7$; $p < 0.001$). After Bonferroni correction, the preoperative–month 1, preoperative–month 6, and month 1–month 6 differences all remained significant (adjusted $p \leq 0.001$). The month-1 rise may be related to steroid response, early postoperative inflammation, or angle narrowing; however, these potential mechanisms were not directly investigated in the present study and should therefore be considered speculative. Although IOP increased at month 1, the elevation did not require IOP-lowering treatment in any of the 21 patients. No eye developed persistent glaucoma or an acute angle-closure crisis.

4. Discussion

This series documents the 6-month nasal and temporal quantitative course of AOD, TISA, and TIA after Eyecryl posterior chamber pIOL implantation using Optopol REVO FC imaging. The principal finding is that angle parameters narrow by approximately one-half during the first month and thereafter reach a plateau. This pattern coincides quantitatively with the 34–42% TIA and 50–58% AOD reductions reported by Fernández-Vigo et al. after ICL V4c implantation on Fourier-domain OCT [9–11]. After IPCL implantation, AOD and TISA likewise declined at 1 month and remained stable at 3 and 6 months [13]; a similar early-plateau pattern has been confirmed in eyes with both spacious and shallow anterior chambers [15].

The reduction in TISA (~59%) was slightly greater than that in AOD (~52%). Because TISA incorporates iris configuration and areal geometry, anterior tenting of the iris by the lens may account for this difference. Symmetric nasal and temporal narrowing in the horizontal meridian is consistent with 360° iris displacement by the convex anterior surface of the implant.

Vault was 578 μm at 1 month and 559 μm at 6 months, and all eyes remained within the 250–750 μm range [16]. In the 7-year Eyecryl series of Kirgiz et al., vault declined to a clinically negligible extent over the long term [4]; our 19-μm reduction over 5 months is in the same

direction. In a dynamic vault comparison of ICL and Eyecryl, photopic–scotopic vault change (DVR) was numerically smaller with Eyecryl than with ICL, although the difference approached but did not reach statistical significance (Eyecryl 54.0 ± 36.4 μm vs ICL 86.5 ± 57.9 μm, $p = 0.078$) [18]; distinct mechanical behaviour of the hydrophilic acrylic material may explain this tendency. The positive associations of 6-month vault with preoperative AWD and axial length should be considered exploratory and hypothesis-generating rather than definitive, particularly given the small sample size. These findings may reflect the contribution of preoperative anterior segment anatomy and ocular dimensions to postoperative vault, but they do not establish a direct role for these parameters in lens sizing [19].

Refractive outcomes accord with the published literature: at 6 months, 85.7% of eyes were within ±0.50 D and all were within ±1.00 D. Yaşa et al. reported a mean spherical equivalent of −0.44 D at 12 months [3], and Çakır et al. documented comparable stability at 5 years [5].

IOP rose at 1 month and declined by 6 months, remaining slightly above the preoperative level. In ICL series, early IOP elevation has been attributed to steroid response, residual viscoelastic, or transient angle narrowing; however, these potential mechanisms were not directly investigated in the present study. The 6-month mean IOP was 17.8 mmHg, and no patient required IOP-lowering treatment during the study period. However, given the small sample size and 6-month follow-up, these findings should not be interpreted as evidence of long-term IOP safety.

Strengths of the study include a single surgeon, a single technician, restriction to high-quality OCT, one eye per patient (the right eye), separate nasal and temporal measurements, and paired analysis of months 1 and 6. Limitations are the small sample (21 patients / 21 right eyes), the exclusion of two patients because of incomplete postoperative follow-up, which may have introduced selection bias, the absence of endothelial cell density and logMAR visual acuity from this dataset, lack of superior–inferior quadrant measurements, the absence of a control group, and the 6-month follow-up.

Clinical implication: angle narrowing after Eyecryl implantation was an early and subsequently stable finding in this cohort. The observed 6-month vault values remained within the commonly cited 250–750 μm range,

but this observation should not be interpreted as evidence of long-term safety given the small sample size and 6-month follow-up. The exploratory associations between higher 6-month vault, preoperative AWD, and axial length may help generate hypotheses regarding anatomical determinants of postoperative vault, but they should not be interpreted as definitive guidance for lens sizing.

5. Conclusions

In eyes implanted with the Biotech Eyecryl posterior chamber phakic IOL, AOD, TISA, and TIA measured with Optopol REVO FC narrow by approximately 42–59% during the first postoperative month and remain stable through month 6. Central vault remains within the commonly cited physiological range and declines slightly. Spherical equivalent approaches emmetropia in a predictable manner. An early rise in IOP may occur and partially regress by 6 months. The observed associations between 6-month vault and preoperative AWD and axial length were exploratory and should be interpreted cautiously. Given the small sample size and limited follow-up, these findings do not establish long-term safety or definitive criteria for lens sizing. Larger studies with endothelial data and 360° angle mapping over longer follow-up are warranted.

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Conflict of Interest

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this manuscript.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author upon reasonable request.

AI Assistance

No AI-based tools were used in the preparation of this manuscript.

Ethics Approval and Consent to Participate

This study was approved by the Samsun University Non-Interventional Clinical Research Ethics Committee (Approval no. 2026/16/24; Date: September 2, 2026). The requirement for informed consent was waived by the ethics committee due to the retrospective nature of the study. All procedures were conducted in accordance with relevant guidelines and regulations.

Author Contributions

Gökhan Özgür: conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, supervision, validation, visualization, writing – original draft, writing – review and editing.

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