Changes in Anterior Chamber Angle and Pupillary Diameter after Implantation of a New Posterior Chamber Phakic Intraocular Lens

Mehmet Emin Sucu (meminsucu@gmail.com)
Idil State Hospital

Yusuf Berk Akbaş
Beyoglu Goz Egitim ve Arastirma Hastanesi: Prof Dr N Resat Belger Beyoglu Goz Egitim ve Arastirma Hastanesi

Alper Agca
dünya göz Hospital

Gökhan Demir
Fatih Sultan Mehmet EAH: Fatih Sultan Mehmet Egitim ve Arastirma Hastanesi

---

Research Article

Keywords: iris, iridocorneal angle, phakic intraocular lens, posterior chamber, pupillography

Posted Date: March 19th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-178396/v1

Abstract

Purpose: To evaluate the effect of the Eyecryl posterior chamber phakic intraocular lens (pIOL) on iridocorneal angle (ICA) parameters, anterior chamber depth (ACD), and pupillary size.

Methods: The medical files of myopic patients who had implantation of the Eyecryl posterior chamber pIOL were reviewed retrospectively. Trabecular-iris space area at 500 and 750µm (TISA500, TISA750), angle opening distances at 500 and 750µm (AOD500, AOD750), anterior chamber depth (ACD), iridocorneal angle (ICA), and pupil diameter under different illumination conditions were analyzed preoperatively, and at 1 and 3 months postoperatively.

Results: Ninety-three eyes of 48 patients were included in the study. The mean age of patients was 31.63 ±4.95 years (range, 21-54). The mean ICA decreased from 49.97° ± 6.33 before surgery to 30.75° ± 5.86 and 30.79° ± 5.74 at 1 and 3 months after surgery, respectively. The mean ACD was reduced from 3.23 ± 0.22 mm before surgery to 2.55 ± 0.34 mm and 2.46 ± 0.28 mm at 1 and 3 months after surgery, respectively. TISA500, TISA750, AOD500, and AOD750 were also reduced significantly after surgery. The mean pupil size under photopic, mesopic and scotopic illuminations decreased insignificantly by 1 month and continued to decrease significantly by 3 months after surgery.

Conclusion: The implantation of the Eyecryl posterior chamber pIOL in myopic patients caused significant changes in anterior chamber parameters including ICA, ACD, TISA 500, TISA 750, AOD 500, AOD 750, and the pupil diameter under different illumination conditions.

Introduction

Implantation of a posterior chamber phakic intraocular lens (pIOL) is an alternative to corneal refractive surgical procedures such as photorefractive keratectomy (PRK), laser in situ keratomileusis (LASIK), and small incision lenticule extraction (SMILE) [1–3]. Posterior chamber pIOLs are designed to be inserted in the posterior chamber behind the iris. Currently, there are only a limited number of posterior chamber pIOL models in the market, and all of them are in direct contact with the posterior surface of the iris. Also, their vault (distance between the phakic lens and the crystalline lens) results in an anterior displacement of the central and peripheral iris and reducing the distance between the posterior surface of the cornea and the iris. Besides, the haptic zone of the pIOLs rest directly behind the iridocorneal angle (ICA) structures.

The Eyecryl pIOL is a new posterior chamber pIOL, and its long-term results are not established in the literature [4, 5]. However, the Visian implantable collamer lens (ICL) (STAAR Surgical Co.) has been widely implanted and resulted in significant changes in the ICA parameters and clinically insignificant changes in pupillary diameter [6]. On the other hand, the influence of a posterior chamber pIOL on the iris and anterior chamber may vary depending on the lens design, size, material, thickness or its vault, and the effects of other posterior chamber pIOLs or the Eyecryl pIOL have not been described in the literature. To describe the spectrum of changes in ICA and pupillary diameter are important because narrowing or

closure of the angle may result in increased intraocular pressure. In addition, a functional pupilla and the pupillary diameter have a significant effect on the optical quality of the retinal image [7–9].

The objective of this study was to evaluate the effect of the Eyecryl posterior chamber pIOL on ACD, ICA, and the pupil size.

Methods

The study adhered to the tenets of the Declaration of Helsinki and approval was obtained from the institutional review board. The medical records of patients who had implantation of the Eyecryl pIOL at the Beyoglu Eye Training and Research Hospital were retrospectively reviewed. Patients with preoperative and postoperative pupillography, corneal topography, and anterior segment OCT measurements were included in the study. Patients with iridocorneal pathologies or previous ocular surgeries were excluded.

Preoperative And Postoperative Examinations

The routine examination procedure of our clinic for phakic IOL implantation surgery includes uncorrected (UDVA) and corrected (CDVA) distance visual acuities, subjective and objective refractions, intraocular pressure (IOP) measurement with a Goldmann applanation tonometer, corneal topography, dynamic pupillography, optical biometry and anterior segment imaging with an anterior segment optical coherence tomography (Visante OCT, Carl Zeiss AG, Germany). The software of the Visante OCT enabled the calculation of trabecular-iris space area at 500 and 750μm (TISA500, TISA750), angle opening distances at 500 and 750μm (AOD500, AOD750) automatically. Corneal topography and dynamic pupillography were performed with a single platform (Sirius, Costruzioni Strumenti Oftalmici, Italy). The pupillometry integrated into the device captured the pupillary diameter dynamically according to the defined (scotopic, mesopic, and photopic) lighting conditions. At day 1 and week 1 visits, only visual acuity and IOP were measured, and a slit-lamp examination was performed. All the other visits were similar to the preoperative visit. Demographical data, visual and refractive results, TISA 500, TISA 750, AOD 500, AOD 750, anterior chamber depth (ACD), and pupillography measurements were analyzed preoperatively, and at 1 and 3 months postoperatively in this study.

Statistical Analysis

IBM SPSS Statistics (Version 22.0, IBM Corp.) was used for statistical analysis. Mean and standard deviation was used to report data. Preoperative and postoperative numerical continuous variables were compared with the aid of the Friedman test with a Bonferonni correction which was used for post hoc analysis to compare two consecutive visits. Spearman's rho test was performed to analyze whether there was a correlation between variables. A p value < 0.05 was considered statistically significant.

Phakic Intraocular Lens

The Eyecryl pIOL (Biotech Vision Care, Ahmedabad, India) is a foldable and hydrophilic posterior chamber pIOL that is made of a copolymer of hydroxyethyl methacrylate and collagen. Its plate haptic design is similar to the ICL. It has an aspherical optic (zero aberration) with a central hole (320 μ m).

Surgical Procedure

All cases were performed by the same surgeon (AA) using sub-tenon anesthesia. Before beginning the operation, the 0- and 180- horizontal axis were marked manually at the slit lamp to prevent the effect of potential cyclotorsion. The surgery was started by placing a Mendez ring on the eye to mark the desired implantation axis. Then, paracentesis was created, and following injection of adrenalin, sodium hyaluronate 1% (Provisc; Alcon Inc., Ft. Worth, TX, USA) was injected into the anterior chamber. The pIOL was inserted in the anterior chamber using the injector system through a temporal corneal incision. The haptics of pIOL was cautiously placed under the iris. Viscoelastic material was removed by washing out with a buffered salt solution, and corneal incisions were hydrated.

Results

Ninety-three eyes of 48 patients [26 females (54.16%), 22 males (54.84%)] were included in this retrospective case series. The mean age of patients was 31.63 ± 4.95 years (range, 21–54). The mean postoperative UDVA and CDVA were 0.21 ± 0.20 logMAR and 0.15 ± 0.21 logMAR at 1 and 3 months postoperatively, respectively. Efficacy index (postoperative UDVA / preoperative CDVA) and safety index (postoperative CDVA / preoperative CDVA) were 1.16 ± 0.31 and 1.33 ± 0.36, respectively.

No intraoperative or postoperative complications were observed. None of the patients developed glaucoma or experienced an angle-closure glaucoma attack. None of the patients lost two or more lines of CDVA.

Preoperative and postoperative characteristics of the eyes and their biometric measurements are listed in Table 1.

Table 1
Preoperative and postoperative characteristics of the eyes and their biometric measurements

	Preoperative	Postoperative		p^a	p^b	p^c
		1 month	3 months			
	Mean ± SD	Mean ± SD	Mean ± SD			
SE (D)	-10.48 ± 3.00	-0.25 ± 0.71	-0.31 ± 0.49	<0.001	0.78	<0.001
Cylinder (D)	-1.95 ± 0.96	-0.32 ± 0.51	-0.25 ± 0.45	<0.001	0.22	<0.001
CDVA (logMAR)	0.25 ± 0.21	0.14 ± 0.19	0.15 ± 0.21	<0.001	0.46	<0.001
Mean K (D)	44.04 ± 1.7	44.08 ± 1.6	44.89 ± 1.6	0.24	0.09	0.07
ACD (mm)	3.23 ± 0.22	2.55 ± 0.34	2.46 ± 0.28	<0.001	0.07	<0.001
ICA (°)	49.97 ± 6.33	30.75 ± 5.86	30.79 ± 5.74	<0.001	0.48	<0.001
TISA 500 (mm^2)	0.18 ± 0.07	0.09 ± 0.03	0.09 ± 0.03	<0.001	0.56	<0.001
TISA 750 (mm^2)	0.36 ± 0.15	0.18 ± 0.05	0.18 ± 0.06	<0.001	0.24	<0.001
AOD 500 (mm)	0.60 ± 0.26	0.28 ± 0.08	0.28 ± 0.08	<0.001	0.13	<0.001
AOD 750 (mm)	0.85 ± 0.31	0.40 ± 0.10	0.39 ± 0.10	<0.001	0.22	<0.001
IOP (mmHg)	15.16 ± 2.44	14.71 ± 4.81	13.55 ± 2.71	0.43	0.56	0.23

p^a: between preoperative and postoperative 1 month

p^b: between postoperative 1 and 3 months

p^c: between preoperative and postoperative 3 months

ACD: anterior chamber depth, AOD 500: angle opening distance at 500 µm, AOD 750: angle opening distance at 750 µm, CDVA: corrected distance visual acuity, IOP: intraocular pressure, ICA: iridocorneal angle, mean K: mean keratometry, SE: spherical equivalent, TISA 500: trabecular-iris space area at 500 µm, TISA 750: trabecular-iris space area at 750 µm, WTW: horizontal white to white.

The horizontal white to white and axial length of the eyes were measured only preoperatively and found to be 11.77 ± 0.28 mm and 27.02 ± 1.50 mm, respectively. The mean postoperative 1 and 3-month vault was 551.75 ± 203.71 µm and 580.55 ± 182.44 µm, respectively.

At 1 month postoperatively, spherical equivalent (SE), CDVA, ACD, ICA, TISA 500, TISA 750, AOD 500, and AOD 750 decreased significantly ($p < 0.001$). Other parameters including the mean keratometry (K) and IOP changed insignificantly with p values of 0.24 and 0.43, respectively.

Table 2 shows changes in pupillary diameter under different light conditions.

Table 2
Preoperative and postoperative changes in scotopic, mesopic, and photopic pupillary diameter

	Preoperative	Postoperative				
		1 month	3 months	p^a	p^b	p^c
Pupillary diameter	**Mean±SD**	**Mean±SD**	**Mean±SD**			
Scotopic (mm)	5.79±0.82	5.65±0.87	5.58±0.86	0.61	0.04	0.01
Mesopic (mm)	5.38±1.03	5.30±0.91	5.18±0.98	0.94	0.001	<0.001
Photopic (mm)	4.48±1.13	4.29±0.89	4.28±1.07	0.24	<0.001	<0.001

p^a: between preoperative and postoperative 1 month

p^b: between postoperative 1 and 3 months

p^c: between preoperative and postoperative 3 months

Although the decrease in pupillary diameter under different light conditions between preoperative and postoperative 1 month was not statistically significant, the changes between 1 and 3 months and between preoperative and postoperative 3 months were statistically significant ($p < 0.05$).

Spearman's rho test was used to analyze whether there was a correlation among anterior segment parameters, pupil diameter, vault, and axial length. No significant correlation was detected among the parameters.

Discussion

The results of our study showed that anterior chamber parameters including ICA, ACD, TISA 500, TISA 750, AOD 500, AOD 750, and the pupil diameter under different light conditions were reduced significantly after the implantation of the Eyecryl pIOL. The change in the mean K and IOP was not statistically significant ($p = 0.07$ and $p = 0.23$, respectively).

We found that ICA decreased by 38.7% and 38.5% at 1 and 3 months after surgery, respectively. The mean ICA dropped from 49.97° ± 6.33 before surgery to 30.75° ± 5.86 and 30.79° ± 5.74 at 1 and 3 months after surgery, respectively. Similarly, decrease of 31.6% and 31.5% in ICA after ICL implantation was found by Elmohamady et al. at 1 and 3 months [6]. Also, Chung et al. evaluated ICA using UBM (ultrasound bio-microscopy) and found a reduction of 31.7% after 1 month [10].

In our study, the mean ACD was reduced from 3.23 ± 0.22 mm preoperatively to 2.55 ± 0.34 mm and 2.46 ± 0.28 mm at 1 and 3 months postoperatively, respectively. The rate of reduction was 21% and 23.8% at 1 and 3 months postoperatively, respectively. Our results were consistent with the study by Ju et al. [10]. They reported a reduction in the mean ACD from 3.28 ± 0.14 mm preoperatively to 2.45 ± 0.22 mm at 3

months postoperatively. Similar results were also found by Elmohamady et al. as 3.59 ± 0.17 mm preoperatively and 2.96 ± 0.25 mm at 3 months postoperatively [6].

In our study, the mean vault was measured as 551.75 ± 203.71 μm and 580.55 ± 182.44 μm at 1 and 3 months after surgery, respectively. Similarly, the mean vault for ICL in the study by Elmohamady et al. was found to be 556 ± 33 μm and 431 ± 56 μm at 1 and 3 months after surgery, respectively [6]. Also, similar vault values were reported for ICL in different studies [10, 11].

Our study showed that the mean pupil diameter under scotopic, mesopic, and photopic illumination conditions was reduced insignificantly by 1 month but significantly by 3 months after surgery. Although Elmohamady et al. found a statistically insignificant reduction in pupil diameter after ICL implantation, a statistically significant reduction in pupil diameter was shown in other studies [6, 15, 16]. Moreover, Zhu et al. reported a significant reduction in pupil diameter under mesopic and photopic illumination conditions and no change under scotopic illumination condition [17]. Similar to Zhu et al., a reduction in pupil diameter under mesopic and photopic illumination conditions after the Eyecryl pIOL was found to be statistically more significant than a reduction under scotopic illumination condition in our study.

The miotic effect of pIOL implantation provides benefits for patients, as it can reduce aberrations that may occur after surgery. On the other hand, the miotic effect may decrease aqueous humor circulation in eyes with a pIOL that has no central hole. Subsequently, the decreased circulation of aqueous humor may result in increased IOP after surgery. In our study, we observed neither clinically decreased circulation of aqueous humor nor increased IOP after surgery.

In the current study, we performed Spearman correlation analysis to assess whether there was a correlation between anterior segment parameters and pupil diameter; however, we did not detect any significant correlation. Inconsistent with our findings, Elmohamady et al. stated a significant positive correlation between the ICL vault and pupil diameter at 1 month postoperatively ($r = 0.9429$, $p < 0.001$) [6]. In line with our results, Li et al. had not found also a significant correlation between the ICL vault and pupil diameter after surgery [15].

The current study has several limitations including retrospective design and relatively short follow-up. Moreover, regarding the change in the pupil, only pupil size was evaluated in the current study; however, pupil contraction amplitude and velocity in light reflexes were not assessed.

In conclusion, we demonstrated that anterior segment parameters including ACD, ICA and angle opening metrics declined significantly by 1 month and changed slightly by 3 months after surgery; however, the mean pupil size decreased insignificantly by 1 month and continued to decrease significantly by 3 months after surgery. The effects of the Eyecryl pIOL on anterior segment parameters and pupil size was similar to that of the ICL demonstrated in previous studies.

Declarations

Funding: No financial support was received.

Conflicts of interest: The authors declare that they have no conflict of interest.

Ethics approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethical approval was received from the University of Health Sciences Turkey, Istanbul Training and Research Hospital Ethics Committee.

Consent to participate: Written informed consent was obtained from all individual participants included in the study.

Consent for publication: Patients signed informed consent regarding publishing their data.

Availability of data and material: The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Code availability: Not applicable.

Authors' contributions: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Yusuf Berk Akbaş and Alper Ağca. The first draft of the manuscript was written by Mehmet Emin Sucu, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

References

1. Dick HB, Alio J, Bianchetti M, Budo C, Christiaans BJ, El-Danasoury MA, Guell JL, Krumeich J, Landesz M, Loureiro F, Luyten GPM, Marinho A, Rahhal MS, Schwenn O, Spirig R, Thomann U, Venter J (2003) Toric phakic intraocular lens; European multicenter study. Ophthalmology 110:150–162
2. Pesudovs K (2005) Wavefront aberration outcomes of LASIK for high myopia and high hyperopia. J Refract Surg 21:S508–S512
3. Keir NJ, Simpson T, Jones LW, Fonn D (2009) Wavefront-guided LASIK for myopia: effect on visual acuity, contrast sensitivity, and higher order aberrations. J Refract Surg 25:524–533
4. Dilek Yaşa B, Köse A, Ağca, "Rotational Stability of a New Posterior Chamber Toric Phakic Intraocular Lens", Journal of Ophthalmology, vol. 2020, Article ID 1624632, 7 pages, 2020
5. Urdem U, Agca A (2019) Refractive results and endothelial cell density after Eyecryl phakic intraocular lens implantation. Beyoglu Eye Journal 4(1):17–22
6. Elmohamady MN, Abdelghaffar W Anterior Chamber Changes After Implantable Collamer Lens Implantation in High Myopia Using Pentacam: A Prospective Study.Ophthalmol Ther 6, 343–349 (2017). https://doi.org/10.1007/s40123-017-0109-3
7. Schwiegerling J (2000) Theoretical limits to visual performance. Surv Ophthalmol 45:139Y46

8. Walsh G, Charman WN (1988) The effect of pupil centration and diameter on ocular performance. Vision Res 28:659Y65
9. Alarco´n A, Rubin˜o M, Pe´e´e´rez-Oco´n F, Jime´nez JR (2012) Theoretical analysis of the effect of pupil size, initial myopic level, and optical zone on quality of vision after corneal refractive surgery. J Refract Surg 28:901Y6
10. Chung SC, Park MO, Lee K, Ahn ES (2009) Chung. Changes in iridocorneal angle structure and trabecular pigmentation with STAAR implantable collamer lens during 2 years. J Refract Surg 25(3):251–258
11. Chen X, Miao H, Naidu RK et al (2016) Comparison of early changes in and factors affecting vault following posterior chamber phakic Implantable Collamer Lens implantation without and with a central hole (ICL V4 and ICL V4c). BMC Ophthalmol 16:161. https://doi.org/10.1186/s12886-016-0336-8
12. Li D, Yang Y, Su C, Yin H, Liu, Xue Pupil Diameter Changes in High Myopes after Collamer Lens Implantation, Optometry and Vision Science: December 2015 - Volume 92 - Issue 12 - p 1161–1169
13. Zhu YMD, He TMD, Zhu HMD, Chen JMD, Zhou, Jibo MD (2019) Static and dynamic pupillary characteristics in high myopic eyes with two implantable collamer lenses. Journal of Cataract Refractive Surgery: July 45(- Issue 7):946–951
14. Lisa CMD, Naveiras, Miguel MD, Alfonso-Bartolozzi, Belén MD, Belda-Salmerón, Lurdes MSc; Montés-Micó, Robert PhD; Alfonso, José F. MD, PhD*Posterior chamber collagen copolymer phakic intraocular lens with a central hole to correct myopia: One-year follow-up, Journal of Cataract & Refractive Surgery: June (2015) - Volume 41 - Issue 6 - p 1153–1159
15. Li D, Yang Y, Su C, Yin H, Liu X (2015) Pupil diameter changes in high myopes after collamer lens implantation. Optom Vis Sci 92(12):1161–1169
16. Chun YS, Park IK, Lee HI, Lee JH, Kim JC (2006) Iris and trabecular meshwork pigment changes after posterior chamber phakic intraocular lens implantation. J Cataract Refract Surg 32:1452–1458
17. Zhu Y, He T, Zhu H, Chen J, Zhou J (2019 Jul) Static and dynamic pupillary characteristics in high myopic eyes with two implantable collamer lenses. J Cataract Refract Surg 45(7):946–951