

Posterior chamber phakic intraocular lenses after penetrating keratoplasty

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PURPOSE: To evaluate the efficacy, predictability, and safety of a phakic posterior chamber intraocular Collamer lens (ICL) after penetrating keratoplasty (PKP).

SETTING: Fernández-Vega Ophthalmological Institute, Oviedo, Spain.

METHODS: A myopic or toric ICL was implanted after PKP in eyes unable to wear glasses or contact lenses and for which corneal laser surgery was contraindicated. The uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), refractive error, and endothelial cell count were recorded preoperatively and 24 months postoperatively.

RESULTS: Preoperatively, the 15 eyes had myopia from -2.00 to -17.00 diopters (D) or astigmatism from -1.50 to -7.00 D. Twenty-four months postoperatively, the mean Snellen decimal UDVA was 0.51 ± 0.30 (SD). The UDVA was 20/40 or better in 7 eyes (46.6%). The mean CDVA was 0.79 ± 0.22 . The CDVA was 20/40 or better in 12 eyes (80%) and 20/25 in 6 eyes (40%). No eye lost more than 1 line of acuity, 2 eyes gained 1 line, and 5 eyes gained more than 2 lines; 8 eyes were unchanged. The safety index was 1.58. The spherical equivalent (SE) was within ± 1.00 D in 80% of eyes and within ± 0.50 D in 66.6% of eyes. The mean postoperative SE was -0.95 ± 1.12 D. At 24 months, the mean vault was 2.06 ± 0.96 and the mean endothelial cell loss, 8.1%.

CONCLUSION: Results indicate that phakic intraocular lens implantation is a viable treatment for myopia and astigmatism after PKP in patients for whom glasses, contact lenses, or corneal refractive surgery are contraindicated.

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Penetrating keratoplasty (PKP) for corneal transplantation is considered safe and effective.^{1,2} However, residual postoperative ametropia remains a problem and contributes to visual limitations after the procedure.³

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Anisometropia and high degrees of refractive error can be a problem for patients who use spectacles or contact lenses for optical correction. Some authors describe contact lens intolerance, graft neovascularization, and endothelial alterations in the postoperative period after PKP.^{4,5} Because of the limitations of spectacle or contact lens correction, several surgical options for correcting refractive error after PKP have been proposed. These include photorefractive keratectomy (PRK),^{6–8} laser in situ keratomileusis (LASIK),^{9–13} piggyback intraocular lens (IOL) implantation,^{14,15} and refractive lens exchange (RLE). Phakic IOL (pIOL) implantation is another option. In a recent paper, Moshirfar et al.¹⁶ report 2 cases in which an anterior chamber pIOL was used successfully to treat high myopia after PKP.

One pIOL, the posterior chamber intraocular Collamer lens (ICL), is reported to provide safe, effective, predictable, and stable visual and refractive outcomes in the correction of myopia,^{17–19} hyperopia,^{18,20}

and astigmatism.^{21,22} In the present study, we describe a series of eyes that had implantation of this pIOL after PKP for the correction of the postoperative refractive error.

PATIENTS AND METHODS

The prospective study was of eyes with previous PKP that had implantation of a myopic or toric pIOL to correct myopia or astigmatism at Fernández-Vega Ophthalmological Institute, Oviedo, Spain. The same surgeon (J.F.A.) performed all surgeries between October 2004 and March 2006. The research followed tenets of the Declaration of Helsinki. All patients provided informed consent after they received an explanation of the nature and possible consequences of the study. An institutional review board gave approval for the study.

The indications for PKP were a corrected distance visual acuity (CDVA) of 20/40 or worse or intolerance to contact lens. The surgical technique and general criteria for the corneal tissue have been described.² The exclusion criteria included age younger than 25 years, anterior chamber depth (ACD) less than 3.0, cataract, history of glaucoma or retinal detachment, macular degeneration or retinopathy, neuro-ophthalmic diseases and a history of ocular inflammation.

Before pIOL implantation, patients had a complete ophthalmologic examination, including manifest and cycloplegic refractions, keratometry, corneal topography, endothelial cell count, pachymetry, slitlamp biomicroscopy, Goldmann applanation tonometry, and binocular indirect ophthalmoscopy through dilated pupils.

To qualify for pIOL implantation, eyes had to have a stable refraction at least 2 years after PKP and less than 2.50 diopters (D) of refractive cylinder (spherical pIOL) or more than 2.50 D of refractive cylinder (toric pIOL). The myopic ICMV4 Visian ICL and toric TICMV4 Visian ICL (both Staar Surgical) are posterior chamber pIOLs of a hydrophilic porcine (scleral tissue), collagen-based, biocompatible material; the 2 models have the same size and thickness.¹⁷⁻²⁰ The pIOLs have a plate-haptic design, a central convex-concave optical zone, and cylinder in the axis. In some patients with refractive cylinder of greater than 2.50 D, a spherical pIOL was implanted because the toric model was not available on the Spanish market at the time. In these cases, 2 opposite clear corneal incisions were made on the steepest meridian after pIOL implantation to reduce refractive cylinder, as is done during phacoemulsification in some eyes.²³ The power of the myopic pIOL was calculated using manufacturer-provided software. The power of the toric pIOL was calculated using the astigmatic decomposition method of Sarver and Sanders.²⁴ This formula calculates the appropriate pIOL cylinder using the manifest refractive cylinder.

Laser iridotomy was performed 1 week before surgery. Cycloplegic and phenylephrine eyedrops were instilled 30 minutes before surgery and povidone-iodine 5%, 5 minutes before surgery. All surgeries were performed using peribulbar anesthesia through a 3.2 clear corneal tunnel incision in the steepest meridian. The anterior chamber was filled with sodium hyaluronate 1% (Provisc), which was completely removed at the end of surgery. Postoperatively, tobramycin-dexamethasone 0.1% eyedrops were used 4 times a day for 10 days, followed by diclofenac sodium eyedrops 4 times a day for 2 weeks.

Postoperative follow-up was at 1 and 7 days and 1, 3, 6, 12, and 24 months. The same ophthalmic technician, who was

unaware of the objective of the study, performed the examinations, which included uncorrected distance visual acuity (UDVA), CDVA, slitlamp evaluation, refraction, funduscopy, and tonometry. Refractions before and 24 months after ICL implantation were assessed for astigmatism using the power vector method.²⁵ Any spherocylindrical refractive error was expressed by 3 dioptric powers: M, J0, J45, with M being a spherical lens equal to the spherical equivalent (SE) of the given refractive error and J0 and J45 being 2 Jackson cross-cylinders equivalent to the conventional cylinders. These numbers are the coordinates of a point in a 3-dimensional dioptric space, being the power vector from the origin of this space to the point (M, J0, J45). Thus, the length of the vector is a measure of the overall blurring strength (B) of a spherocylindrical refractive error. Manifest refractions in conventional script notation (S [sphere], C [cylinder] × α [axis]) were converted to power vector coordinates and overall blurring strength by the following formulas: $M = S + C/2$; $J0 = (-C/2) \cos(2\alpha)$; $J45 = (-C/2) \sin(2\alpha)$; $B = (M^2 + J0^2 + J45^2)^{1/2}$.

Data reported here are from the 24-month examination. Statistical analysis was performed using SPSS for Windows (version 12.0, SPSS, Inc.). Normality was checked by the Shapiro-Wilk test. The univariate *t* test and Hotelling T^2 test of multivariate statistics were used for astigmatism analysis. A series of 3 univariate *t* tests were performed to test the hypothesis that the 3 components of the power vector analysis (M, J0, J45) had a mean that was not statistically different from zero; that is, that the refractive error was adequately corrected after surgery. Differences were considered statistically significant when the *P* value was less than 0.01 (ie, at the 1% level).

RESULTS

The study comprised 15 eyes of 15 consecutive patients with a mean age of 37.8 years \pm 9.37 (SD) (range 27 to 57 years). The mean myopia was -7.08 ± 4.34 D (range -2.00 to -17.00 D) and the mean cylinder, -3.45 ± 1.63 D (range -1.50 to -7.00 D). The mean ACD was 3.46 ± 0.34 (range 3.04 to 4.01). Implantation of the pIOLs was performed a mean of 3.35 ± 2.34 years after PKP. Table 1 shows the preoperative and 24-month postoperative data.

There were no intraoperative complications. Postoperatively, no eye required pIOL explantation or repositioning and there were no cases of decentration of the pIOL optic. No patient reported halos and glare under daylight or dim conditions. No eye developed intraocular pressure higher than 21 mm Hg, and there were no cases of pupillary block.

The mean vault was 2.06 ± 0.96 (range 2.0 to 4.0). The mean corneal thickness was 490.3 ± 48.3 μ m (range 398 to 533 μ m). The mean endothelial cell density (ECD) was 1660 ± 427 cell/mm² preoperatively and 1526 ± 398 cell/mm² 24 months postoperatively. No eye had evidence of corneal decompensation. Figure 1 shows a spherical pIOL in an eye 24 months after surgery.

The mean UDVA (Snellen decimal) at 24 months was 0.51 ± 0.30 (range 0.1 to 1.0). The UDVA was

Table 1. Preoperative and 24-month postoperative data.

Eye	Age (Y)/ Sex	Kmin/ Kmax (D)	Preoperative					Postoperative						
			Sphere(D)	Cyl (D)	Axis (Deg)	CDVA	ACD	ICL Power (D)/ (Cylinder [D])* Diameter	Sphere (D)	Cyl (D)	Axis (Deg)	UDVA	CDVA	Vault
1	31/F	44.5/50.0	-10.00	-3.00	50	20/32	3.17	-16.50/11.50	0.00	0.00	—	20/32	20/32	3
2	27/F	39.5/46.8	-4.00	-7.00	160	20/32	3.90	-13.00 (6.00)/12.50	0.00	-0.50	150	20/40	20/32	2
3	41/F	43.0/44.0	-4.00	-1.50	80	20/50	3.95	-6.50/12.00	0.00	0.00	—	20/50	20/50	3
4	47/M	51.0/55.0	-7.00	-3.00	50	20/200	3.18	-11.00/11.50	0.00	-2.50	40	20/200	20/100	3
5	53/F	40.0/47.8	-8.00	-5.00	165	20/63	3.28	-13.00/12.00	-0.50	-2.25	150	20/200	20/40	2
6	32/M	44.3/47.8	-9.00	-4.00	85	20/32	3.19	-18.50 (5.00)/12.50*	0.00	0.00	—	20/20	20/20	2
7	29/F	46.0/51.8	-2.25	-5.00	5	20/32	3.30	-9.50 (6.00)/12.00*	0.00	-0.50	0	20/32	20/32	2
8	28/M	42.5/47.5	-3.00	-5.00	15	20/32	3.08	-10.00 (5.00)/12.00*	-3.00	-0.75	5	20/160	20/25	2
9	33/F	46.8/51.8	-17.00	-4.50	80	20/50	3.57	-20.00/12.00	-1.50	-3.25	75	20/100	20/40	3
10	44/F	54.0/54.5	-12.50	-1.00	90	20/50	3.82	-19.00/12.00	-1.00	0.00	—	20/32	20/25	3
11	57/F	43.3/47.3	-9.00	-3.25	15	20/63	4.01	-17.50 (4.50)/11.50*	0.00	-1.00	90	20/125	20/63	4
12	31/F	40.3/44.0	-2.00	-2.50	18	20/25	3.05	-6.50 (3.50)/12.00*	-2.00	0.00	—	20/125	20/25	2
13	42/M	41.0/43.5	-2.00	-2.50	85	20/25	3.15	-8.00 (4.50)/11.50*	0.00	0.00	—	20/25	20/25	2
14	40/F	47.5/48.5	-10.00	-1.50	90	20/50	3.73	-16.50/12.50	0.00	-0.50	0	20/25	20/20	2
15	32/F	40.8/44.8	-6.50	-3.00	80	20/32	3.57	-10.50/12.00	0.00	-1.50	15	20/50	20/32	2

ACD = anterior chamber depth; CDVA = corrected distance visual acuity; Deg = degrees; ICL = intraocular Collamer lens; Kmax = maximum keratometry reading; Kmin = minimum keratometry reading; UDVA = uncorrected visual acuity

*Toric lens

20/40 or better in 7 eyes (46.6%). The mean CDVA was 0.50 ± 0.18 (range 0.1 to 0.6) preoperatively and 0.79 ± 0.22 (range 0.2 to 1.0) postoperatively; the difference was statistically significant ($P = .0011$). The CDVA was 20/40 or better in 12 eyes (80%) and 20/25 or better in 6 eyes (40%). The overall efficacy index (mean postoperative UDVA/mean preoperative CDVA) at 24 months was 1.02 (Figure 2). No eye lost 1 or more lines of acuity (Figure 3). Two eyes gained 1 line, 2 eyes gained 2 lines, and 3 eyes gained more than 2 lines of CDVA; 8 eyes remained unchanged. The safety index (ratio of postoperative CDVA to preoperative CDVA) at 24 months was 1.58.

Figure 4 shows the attempted refraction versus the achieved refraction. For M, 80.0% of eyes were within ± 1.00 D of the desired refraction and 66.6% were within ± 0.50 D. The mean M value was -0.95 ± 1.12 D at 24 months. For J0, all eyes were within ± 0.50 D. For J45, 93.3% of eyes were within ± 1.00 D and 73.3% were within ± 0.50 D. Figure 5 shows the astigmatic component of the power vector represented by the 2-dimensional vector (J0, J45). The origin of the graph (0,0) represents an eye free of astigmatism. The spread of the postoperative data from the origin is more concentrated than the spread of the preoperative data.

Table 2 shows the distribution of the preoperative and postoperative manifest refractive errors after vector conversion. There was a large reduction (approximately 80%) in blur strength after implantation, showing that the relatively wide range of refractive

errors was reduced to a narrow distribution that was near emmetropia. The power vector magnitude was reduced after surgery, and there was compression of the overall refractive error data, as shown by the reduction in the standard deviations. The 3 monovariate t tests to determine whether the refractive error was adequately corrected showed no statistically significant difference from zero ($P = .598$ for M; $P = .498$ for J0; $P = .5311$ for J45). A multivariate Hotelling T^2 test confirmed that the mean power vector after surgery was not significantly different from a vector of zero length ($P = .815$); that is, the surgery corrected the myopia and astigmatism.

DISCUSSION

This prospective study evaluated 15 eyes that had implantation of a phakic posterior chamber ICL to correct myopia or astigmatism after previous PKP. To our knowledge, there are no studies of the implantation of this type of pIOL after PKP. The aim of the present study was to determine whether this surgery is a good alternative for correcting refractive errors after PKP. Although contact lenses, spectacles, corneal laser surgery, and lens extraction are viable options in this group of eyes, these options were not appropriate in our patients for several reasons. These included contact lens intolerance because of dry eye, spectacle intolerance due to anisometropia, contraindication to PRK or LASIK because of high myopia and astigmatism

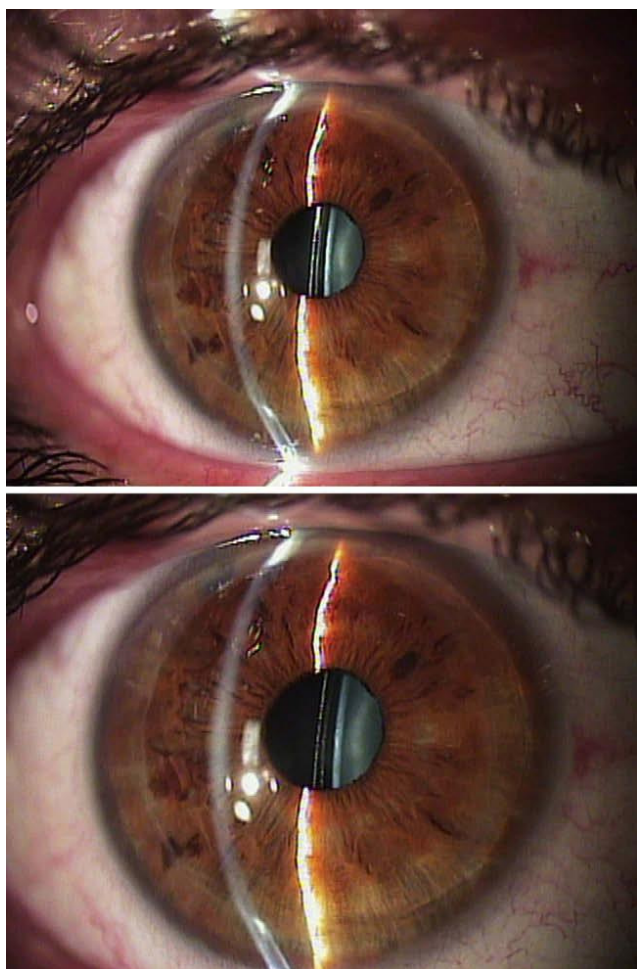


Figure 1. The spherical ICL in case 3 at 24 months.

and a low baseline corneal thickness, and young age; in some cases, RLE was also not appropriate.

The visual outcomes in our study were satisfactory based on the safety index (1.58), with most eyes maintaining preoperative CDVA and some gaining multiple lines. By the 24-month follow-up, no eye had lost 1 or more lines of CDVA and 46% had gained 1 or more lines. Fifty-two percent of eyes had no change in CDVA from preoperatively. After pIOL implantation, 80% of eyes had a CDVA of 20/40 or better at 24 months ($P < .01$). Postoperatively, the efficacy index was good (1.02) and blur strength was greatly reduced (from 5.03 D to 1.10 D). Predictability was also good, with 80.0% of eyes within ± 1.00 D of the desired refraction and 66.6% within ± 0.50 D for the M value. The mean M value was less than 1.00 D (-0.95 ± 1.12 D). For the astigmatic components J0 and J45, almost all eyes were within ± 1.00 D.

The U.S. Food and Drug Administration (FDA) performed studies of the safety, efficacy, and predictability of myopic ICL and toric ICL implantation. In the 3-year FDA myopic ICL study¹⁷ (M value: mean

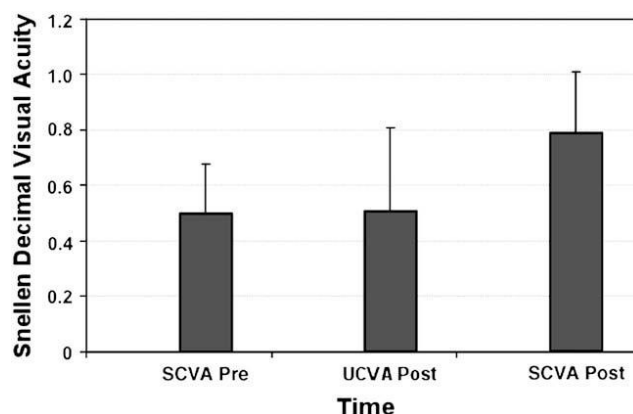


Figure 2. Preoperative and 24-month postoperative UDVA and CDVA (efficacy) (CDVA = corrected distance visual acuity; UDVA = uncorrected distance visual acuity).

-10.06 ± 3.74 D and range -3.00 to -20.00 D), 94.7% of patients had a UDVA of 20/40 or better; 67.5% were within ± 0.50 D of the predicted refraction and 88.2% were within ± 1.00 D. The mean improvement in CDVA ranged from 0.5 to 0.6 lines. Three eyes (0.8%) had a decrease in CDVA of 2 or more lines, and 40 eyes (10.8%) had an increase of a similar amount. In the 1-year FDA toric ICL study²¹ (M value: mean -9.36 ± 2.66 D and range -2.38 to -19.5 D; astigmatism: mean -1.93 ± 0.84 D and range 1.00 to 4.00 D), 76.5% of patients had a postoperative UDVA that was as good as or better than the preoperative CDVA. Of the eyes, 76.9% were within ± 0.50 D of the predicted refraction and 97.3% were within ± 1.00 D. The mean improvement in CDVA was 0.88 lines; 1.6% of eyes lost 2 or more lines of CDVA, and 18.9% had an increase of a same amount. Of the eyes, 76.4% gained 1 or more lines of CDVA and 7.5% lost the equivalent amount.

No direct comparison with previous studies of ICL implantation in post-PKP eyes is possible because our study is the first to evaluate the procedure. However,

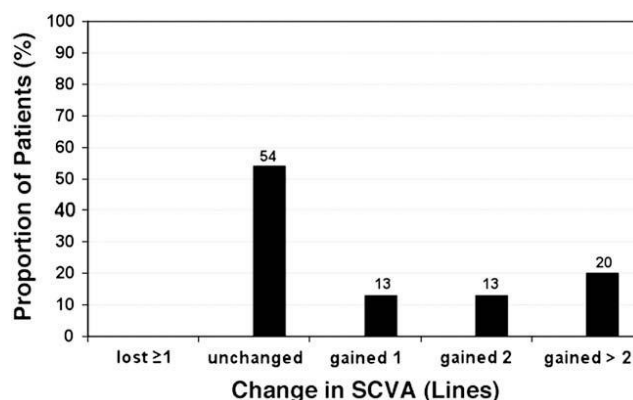


Figure 3. Changes in CDVA from preoperatively to 24 months postoperatively (safety) (CDVA = corrected distance visual acuity).

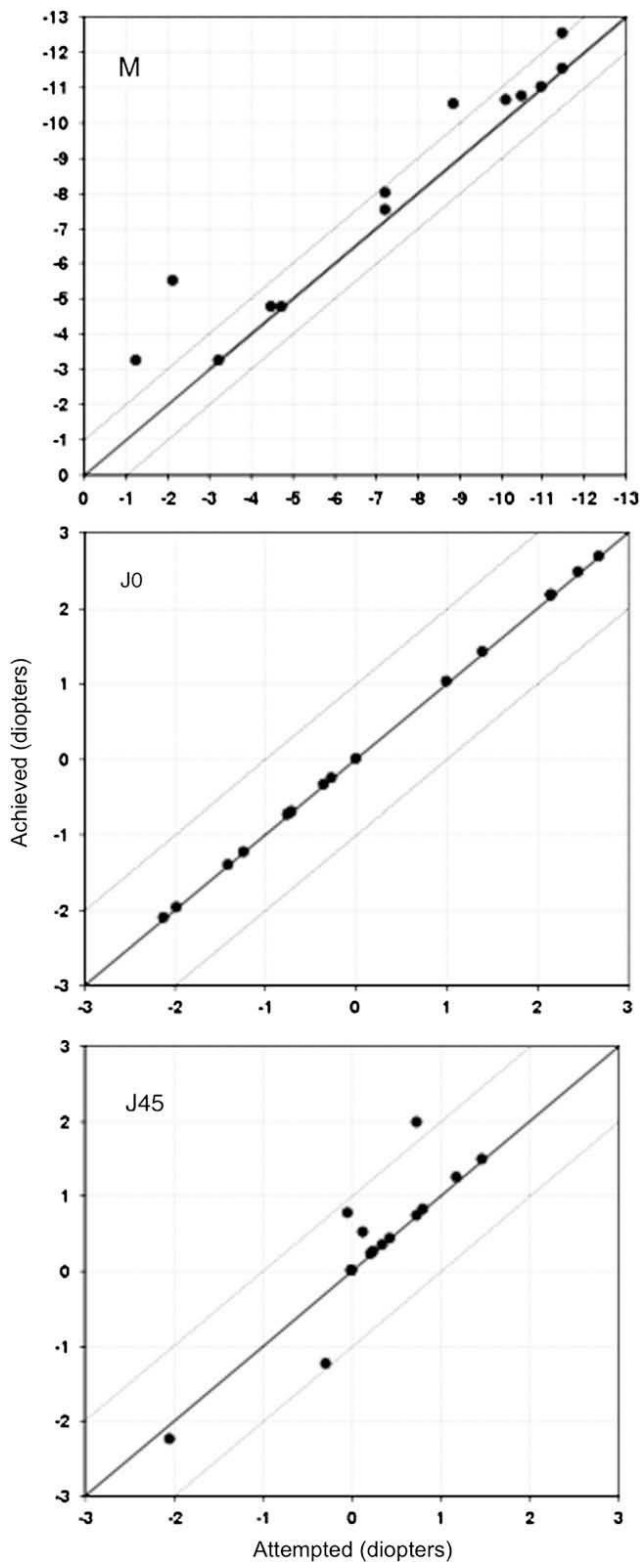


Figure 4. Attempted versus achieved SE (M) and the astigmatic components (J0 and J45) of the power vector analysis.

a study by Moshirfar et al.¹⁶ evaluated the Artisan anterior chamber pIOL for correcting residual ametropia in this groups of patients. The authors report 2

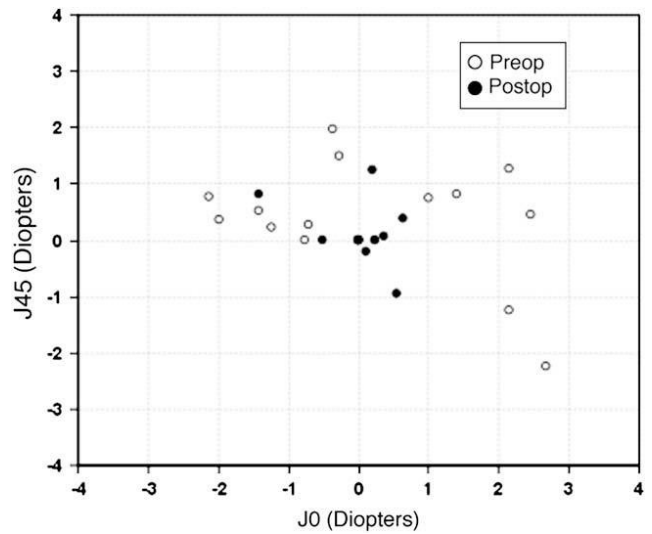


Figure 5. Representation of the astigmatic vector (J0 and J45) before and 12 months after myopic ICL implantation.

eyes in which the pIOL was used to treat high myopia after PKP; in 1 eye, the refraction was $-13.75 + 3.00 \times 50$ and in the other, $-10.75 + 2.25 \times 122$. The CDVA improved from 20/40⁻² to 20/30⁺³ in 1 eye after 9 months; there was no change in CDVA (20/40) in the other eye at 10 months. The ECD did not change significantly in either eye postoperatively, and the authors concluded that implantation of the pIOL could be an alternative method to correct high myopia after PKP.

Table 3 shows the main outcomes in several studies⁹⁻¹⁶ of secondary procedures after PKP for refractive error correction, including LASIK, piggyback IOL implantation, and anterior chamber pIOL implantation, and compares the results with those in our study. Photorefractive keratectomy studies after PKP were not included because of the potential advantages of LASIK over PRK, including a more regular ocular surface with LASIK flaps²⁶ and better corneal sensation postoperatively.²⁷ Bilgihan et al.⁸ report that PRK to correct refractive error after PKP cases appears to be

Table 2. Summary of distribution of manifest refractive errors before and 24 months after ICL implantation following the power vector method.

Value	Before ICL Implantation				After ICL Implantation			
	M	J0	J45	B	M	J0	J45	B
Mean	-4.89	0.10	0.18	5.03	-0.95	0.03	0.08	1.10
SD	4.28	1.65	0.98	4.19	1.12	0.48	0.47	1.19

B = overall blurring strength B of spherocylindrical refractive error; ICL = intraocular Collamer lens; J0 = Jackson cross-cylinder, axes at 180 degrees and 90 degrees; J45 = Jackson cross-cylinder, axes at 45 degrees and 135 degrees; M = spherical lens equal to the spherical equivalent of the given refractive error

Table 3. Outcomes in studies of secondary procedures after PKP.

First Author	Eyes	Presurgery		Postsurgery			
		Mean SE (Range)	Surgery	Mean Residual Ametropia (Follow-up [Mo])	UDVA (% of Patients)	SE Within (% of Patients)	Lines of VA Lost (% of Patients)
Donnenfeld ⁹	23	-7.58 ± 4.42	LASIK	-0.79 ± 1.84 (3)	≤20/40 (36)	±1.00 (59)	1 (4) ≥2 (4)
Forseto ¹⁰	22	-4.55 ± 3.66 (-1.00 to -15.75)	LASIK	-0.67 ± 1.24 (18)	≤20/40 (54)	±0.50 (45)	1 (14) 2 (9)
Kwitko ¹¹	14	Myopic -7.51 ± 3.87 Hyperopic +4.41 ± 2.20	LASIK	Myopic -1.25 ± 2.30 (12) Hyperopic -0.80 ± 1.12 (12)	≤20/25 (14) ≤20/40 (29)	±0.50 (29) ±0.50 (50)	1 (36)
Malecha ¹²	20	-4.24 ± 2.81	LASIK	-0.85 ± 0.84 (14)	≤20/25 (25)		1 (25) ≥2 (5)
Buzard ¹³	26	-4.94 ± 2.79 (-0.50 to -13.50)	LASIK	-0.35 ± 0.65 (24)	≤20/25 (26)	±0.50 (57)	1 (18)
Gayton ¹⁴	7	3.41 ± 1.15* (2.38 to 5.12)	Piggyback IOL	0.98 ± 0.81* (8)	<20/40 (57)	±0.50 (57)	—
Paul ¹⁵	6	-8.08 (-6.13 to -12.00)	Piggyback IOL	-0.94 (7)	≤20/40 (66)	±1.50 (66)	1 (16)
Moshirfar ¹⁶	2	-10.93 ± 1.85 (-10.75 to -13.75)	Anterior pIOL	0.56 ± 0.26 (10)	≤20/40 (50)	±0.50 (50)	≥1 (0)
Present study	15	-9.80 ± 5.88 (-19.25 to -3.25)	Posterior pIOL	-0.95 ± 1.12 (24)	≤20/40 (33)	±0.50 (66)	≥1 (0)

Means ± SD
pIOL = phakic intraocular lens; LASIK = laser in situ keratomileusis; SE = spherical equivalent; UDVA = uncorrected distance visual acuity; VA = visual acuity
*Mean absolute deviation from emmetropia

less effective and less predictable than PRK for naturally occurring myopia and astigmatism; corneal haze and refractive regression were more prevalent, and patient satisfaction was low.

Studies of LASIK⁹⁻¹³ report similar outcomes for residual ametropia (approximately 1.00 D), safety (8% to 36% lost ≥1 line), and predictability (approximately 50% within ±0.50 D). Sources of variability between studies may come from differences in the amount of pre-LASIK ametropia, the laser system used for excimer ablation, and the length of follow-up. Studies by Gayton¹⁴ and Paul et al.¹⁵ of piggyback IOL implantation after PKP show less predictable results than those after LASIK enhancement (57% within ±0.50 D and 66% within ±1.50 D, respectively). However, the use of LASIK is limited in the higher ranges of myopia because it can cause unpredictability, regression, weakening, and dehiscence of the corneal graft interface; therefore, piggyback IOL implantation remains an option. Gayton and Paul et al. discuss the possibility of performing RLE in these patients; however, they point out that the power of a second piggyback IOL is more predictable than in IOL exchange because in the latter, the surgeon may not be certain of the power of the original IOL and the IOL used in the exchange might not be in the same plane as the original IOL.¹⁴ Based on

the results in these 2 studies,^{14,15} piggyback IOL implantation is a good choice for refractive error correction in pseudophakic patients with high degrees of ametropia after PKP for whom LASIK is contraindicated. Multifocal piggyback IOL implantation is safe and effective²⁸ and may be another way to provide pseudoaccommodation in patients after PKP.

A study by Moshirfar et al.¹⁶ and our study evaluated the results of implanting a pIOL in young patients with good accommodation to provide good distance and near vision. Both studies found excellent UDVA with a high degree of predictability; no patient lost more than 1 line of visual acuity, unlike patients in the studies of LASIK and piggyback IOL implantation in Table 3. In our study, the preoperative M value ranged between -3.25 D and -24.00 D and 66% of eyes achieved a postoperative M value within ±0.50 D of the predicted value. Differences between and complications of anterior angle-supported IOLs, iris-fixed pIOLs, and posterior pIOLs have been well described.²⁹ After PKP, implantation of a pIOL seems to provide better results than LASIK, piggyback IOL implantation, or RLE. This is because pIOL implantation does not require manipulation or removal of corneal tissue or of the crystalline lens. The reversibility of pIOL implantation should also be considered.

There is some concern about the possibility of accelerated endothelial cell loss in eyes with a pIOL. Moshirfar et al.¹⁶ evaluated an Artisan pIOL in 2 eyes and found that the ECD did not change significantly postoperatively. The mean cell loss at 24 months in our study was approximately 8.1% (4% per year). The 3-year FDA myopic ICL study¹⁷ had a cumulative corneal endothelial cell loss of less than 10% (3.2% per year). In eyes with corneal transplantation, the endothelial cell loss rate is reported to be 7.8% per year at 3 to 5 years³⁰ and approximately 4.2% at 5 to 10 years.³¹ Our results were similar to those previously found after corneal transplantation and pIOL implantation. Long-term evaluation of post-PKP eyes with a pIOL should be performed to assess the percentage rate.

No patients in our study developed crystalline lens opacities. In the 3-year myopic FDA ICL study,¹⁷ early, largely asymptomatic, and presumably surgically induced anterior subcapsular opacities (trace or greater) were seen in 2.7% of eyes. Nuclear opacities of grade 2 or higher 2 to 3 years postoperatively developed in 0.9% of eyes. Sanders³² recently analyzed anterior subcapsular opacities and cataracts 5 years postoperatively in the FDA ICL trial and found that approximately 6% to 7% of eyes developed anterior subcapsular opacities 7 or more years after ICL implantation. However, only 1% to 2% progressed to clinically significant cataract during the same period and they were mostly eyes of older patients and those with very high myopia. Another consideration in post-PKP eyes is the risk for opacities that are mainly caused by antirejection medication.

In our study, there were no intraoperative or postoperative complications. However, long-term randomized comparative prospective studies are necessary to evaluate this technique and its possible complications. Our medium-term outcomes are encouraging. Therefore, ICL implantation in post-PKP eyes may be a good alternative for correcting myopia and astigmatism. Long-term results with a larger sample of patients are needed to assess the predictability of the technique. Future studies should include hyperopic pIOLs.

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