

Clinical Outcomes Using a Trifocal Intraocular Lens in Eyes After Previous Laser Corneal Refractive Surgery or Radial Keratotomy: 1-Year of Follow-Up

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Purpose: To show the clinical outcomes after implantation of a diffractive trifocal intraocular lens (IOL) in eyes with previous laser-corneal-refractive-surgery (LCRS) or radial keratotomy (RK).

Methods: Eyes with previous LCRS (LASIK/PRK group) or RK (RK group) implanted with a diffractive trifocal IOL were enrolled in this retrospective study. Refraction and monocular Snellen decimal uncorrected-distance visual acuity (UDVA), corrected-distance visual acuity (CDVA), and uncorrected-near visual acuity (UNVA) were analyzed at 1-year.

Results: The current study comprises 124 eyes: 102 eyes for the LASIK/PRK group and 22 eyes for the RK group. In the LASIK/PRK group 92.16% of eyes were within $\pm 0.50D$ and 99.02% within $\pm 1.00D$ (mean spherical equivalent of $-0.03 \pm 0.30D$). 91.18% of eyes showed 0.50D or less astigmatism, and all of them 1.00D or less (mean refractive cylinder of $-0.21 \pm 0.27D$). In the RK group, 81.82% eyes were within $\pm 0.50D$ and 100% within $\pm 1.00D$, with a mean SE of $-0.17 \pm 0.38D$. 68.18% eyes showed 0.50D or less residual astigmatism, and 95.45% eyes 1.00D or less, with a mean cylinder of $-0.45 \pm 0.39D$. The mean UDVA, CDVA and UNVA were 1.04 ± 0.19 , 1.14 ± 0.20 and 0.99 ± 0.04 , respectively, for the LASIK/PRK group, and 0.90 ± 0.10 , 1.01 ± 0.08 and 1.00 ± 0.00 , respectively, for the RK group. For the LASIK/PRK group 72.55%, 88.24% and 98.04% of eyes had 20/20 or better UDVA, CDVA and UNVA, respectively, with 96.08%, 100% and 98.04% of eyes achieving 20/25 or better for UDVA, CDVA and UNVA, respectively. For the RK group, the percentages changed to 45.55%, 83.36%, 100%, 90.91%, 100% and 100%, respectively.

Conclusion: The use of a diffractive trifocal IOL can provide good clinical outcomes in eyes with previous LCRS or RK.

Keywords: trifocal, corneal laser, radial keratotomy, refractive surgery, intraocular lens, cataract

Introduction

Laser corneal refractive surgery (LCRS) is one of the most common surgical treatments used specifically for refractive correction.¹ Taking into account that patients who had LCRS have been aging, an increasing number of these subjects are confronted with presbyopia and/or cataract and are in demand to undergo refractive lens exchange or cataract surgeries. Considering that these patients were accustomed to be spectacle-independent after their LCRS, they demonstrate a strong interest not to use glasses at any distance (far, intermediate and near) after their intraocular surgery. In a demographic study of patient having cataract surgery after laser-insitu keratomileusis (LASIK), it has been concluded that patient age at the time of cataract surgery in post-LASIK patients was about 10 years younger than in axial length-matched patients, and about 15 years younger than in the whole population.²

After a Bayesian network meta-analysis comparing various monofocal and multifocal intraocular lenses (IOL) randomized clinical trials consider that trifocal IOL's would be an optimal option to be spectacle-free.³ These lenses may achieve better intermediate visual acuity than patients implanted with bifocal IOLs⁴ and improved near visual acuity

in comparison to enhanced depth-of-focus (EDOF) IOLs.⁵ The optics, design and shape of the IOL surface⁶ are the main differences in multifocal IOLs to correct presbyopia and actual IOLs must provide increased quality and optical performance⁷ to improve reading performance.⁸ Therefore, the use of trifocal IOLs in post-LCRS patients may offer an optimal solution to maintain spectacle independence, as shown in some previous studies.^{9–16} These studies have analyzed eyes with previous photorefractive keratectomy (PRK), LASIK, or laser subepithelial keratomileusis (LASEK) surgeries implanted with different trifocal IOLs in a short follow-up (3–6 months). In addition, in our center we also see patients who have undergone radial keratotomy (RK) to correct their myopia: cataract/lens surgery is less predictable in these patients¹⁷ with hyperopic results due to the RK incisions' flattening.¹⁸ Specifically, some studies and case reports have been published using bifocal, trifocals or EDOF IOLs with small samples and short follow-up.^{19–23}

Taking into account that the number of LASIK and PRK patients is growing and RK patients are also examined in our center, further investigations with these types of eyes implanted with trifocal IOLs, specifically with large samples and longer follow-ups, are required to provide clinical support to make evidence-based decisions in our clinical practice. So, the main objective of the current clinical study is to assess the visual and refractive outcomes in a cohort of eyes with previous LASIK, PRK or RK implanted with a trifocal diffractive IOL at 1 year of follow-up.

Patients and Methods

Study Design and Patients

This was a retrospective-single-center case series study enrolling eyes with previous LCRS (LASIK/PRK) or RK that had undergone cataract or refractive lens exchange (RLE) surgeries with a trifocal diffractive IOL implantation. 124 eyes of 62 patients at the Brussels Eye Doctors center (Belgium) between 2023 and 2024 were examined. The study was carried out in accordance with the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of the Brussels Eye Doctors Center. Informed consent was obtained from all the patients participating in this study. The study inclusion criteria were as follows: eyes implanted with a trifocal (spherical or toric model) after cataract or RLE surgeries with a previous LCRS (LASIK or PRK) or RK, in subjects older than 40 years, and who are interested not to use spectacles after the procedure. The exclusion criteria included keratoconus and any ocular disease (eg macular degeneration, cystoid edema) that may affect post-operative visual outcomes.

IOLs and Surgical Procedure

All the eyes were implanted with FineVision Micro F or POD F toric IOLs (BVI Inc., USA). All eyes underwent the phacoemulsification with the AMO-Signature device (J&J Vision Inc., USA) through a 1.9–2.2 mm temporal incision using topical anesthesia with IOL implantation in the capsular bag.

Pre-Operative and Post-Operative Measurements

All the eyes underwent a complete pre-operative ocular assessment that included slit-lamp and fundoscopic examinations, intraocular pressure measurement, subjective refraction measurement, monocular uncorrected-distance and corrected-distance visual acuity (UDVA and CDVA), and ocular biometry with an IOLMaster 700 (Carl Zeiss Meditec, Jena, Germany) to record ocular parameters for the lens calculation. Not the SRK-T, Haigis or Hoffer-Q formulas were used for IOL power calculations in both groups (LASIK/PRK and RK) but the ASCRS (American Society of Cataract and Refractive Surgery) calculator, with emmetropia target. In case of doubt a very slight myopia was preferred over a small hyperopia. In case of astigmatism, manifest refraction and the keratometry (as measured by the auto-refractometer and the IOL-master) were taken in account to determine whether a toric IOL needed to be implanted.

At 1-year after the surgery, we measured subjective manifest refraction (sphere, cylinder, and axis), keratometry, Snellen decimal monocular UDVA and CDVA, and uncorrected near visual acuity (UNVA) at 40 cm. Manifest refractions were converted to power vector coordinates.²⁴ Any complication during the surgery and follow-up related to the IOLs were also recorded. The % of eyes with Nd:YAG laser capsulotomy procedures after trifocal IOL implantation was recorded.

Analysis

The analysis considered data for demographics, refraction, and visual outcomes. It was conducted using Excel (version 16.43-, Microsoft-Corporation, USA), showing the mean, standard deviation and ranges. Different graphs for cataract surgery with an IOL were created.²⁵

Results

A total of 124 eyes of 62 patients were considered in this study, 51 patients in the LASIK/PRK group and 11 in the RK group. The mean age was 67.10 ± 7.38 years in the LASIK/PRK group, and 66.65 ± 5.33 years in the RK group. Both groups had undergone cataract or RLE surgeries with the Finevision IOLs implantation. Table 1 shows a summary of the demographics and pre-operative data of our sample as a function of the group.

Specifically, for the LASIK/PRK group 92 eyes had LASIK and 10 eyes had PRK. Sixty-seven eyes were implanted with the Finevision Micro F IOL and 35 with the FineVision POD F toric IOL. The mean spherical IOL power was 21.38 ± 2.57 D and the mean cylindrical power was 1.36 ± 0.47 D. The mean time elapsed between the LCRS and IOL surgery

Table 1 Demographics and Characteristics of Eyes Shown as Means, Standard Deviations (SD) and Ranges for the Two Groups of Patients Analyzed

	LASIK/PRK Group	RK Group
Patients (n)	51	11
Sex (male/female)	26/25	5/6
Age (years)	67.10 ± 7.38 (52 to 81)	66.65 ± 5.33 (58 to 75)
Eyes (n)	102	22
LCRS Type		
LASIK (n)	92	–
PRK (n)	10	–
IOL Model		
Spherical (n)	67	7
Toric (n)	35	15
Sphere (D)	0.19 ± 2.12 (–7.00 to 3.75)	1.66 ± 1.69 (–2.25 to 6.25)
Cylinder (D)	$–0.65 \pm 0.43$ (–1.50 to 0.00)	$–0.75 \pm 0.57$ (–1.50 to 0.00)
Spherical equivalent (D)	$–0.14 \pm 2.16$ (–7.00 to 3.40)	1.28 ± 1.57 (–2.50 to 5.50)
UDVA (Snellen Decimal)	0.54 ± 0.27 (<0.05 to 1.20)	0.55 ± 0.28 (0.10 to 1.20)
CDVA (Snellen Decimal)	1.07 ± 0.28 (0.40 to 1.50)	1.08 ± 0.19 (0.70 to 1.50)
K1 (D)	41.62 ± 2.73 (35.25 to 48.00)	37.76 ± 1.54 (35.00 to 40.75)
K2 (D)	42.65 ± 2.87 (36.25 to 48.50)	38.93 ± 1.87 (36.00 to 44.00)
Axial length (mm)	24.11 ± 1.57 (21.42 to 27.85)	25.06 ± 0.91 (23.83 to 26.80)
Spherical IOL power (D)	21.38 ± 2.57 (15.00 to 26.00)	23.77 ± 2.16 (21.00 to 30.00)
Cylindrical IOL power (D)	1.36 ± 0.47 (1.00 to 3.00)	1.57 ± 0.55 (1.00 to 3.00)

Abbreviations: LCRS, laser corneal refractive surgery; LASIK, laser in situ keratomileu-
sis; PRK, photorefractive keratectomy; IOL, intraocular lens; D, diopter; UDVA, uncor-
rected distance visual acuity; CDVA, corrected distance visual acuity; K, keratometry.

was 8.22 years (from 2 to 27 years) and the mean SE before IOL surgery was -0.14 ± 2.16 D (from -7.00 to $+3.50$ D). All patients completed 1-year of postoperative follow-up. There were no adverse events related to the IOL during the follow-up and Nd:YAG laser capsulotomy was performed in 3 eyes (2.94%). For the RK group 7 eyes were implanted with the FineVision Micro F IOL and 15 with the FineVision POD F toric IOL. The mean spherical IOL power was 23.77 ± 2.16 D and the mean cylindrical power was 1.57 ± 0.55 D. The mean time elapsed between the RK and the implantation of the IOL was 6 years (from 2 to 9 years) and the mean SE before IOL surgery was 1.28 ± 1.57 D (from -2.50 to $+5.50$ D). Note that these surgeries were done long time ago since RK was ceased to be carried out, and we included only these patients with a postoperative follow-up of 12 months. There were no complications related to the IOL during the follow-up and no Nd:YAG laser capsulotomy was performed.

Refractive Error

Figure 1 shows the refractive outcomes at 12 months in both groups for the whole sample and as a function of the refractive error before FineVision intraocular lens implantation. At this time, for the LASIK/PRK group (Figure 1A), 94 eyes (92.16%) were within ± 0.50 D and 101 eyes (99.02%) were within ± 1.00 D. The average SE obtained was -0.03 ± 0.30 D (from -1.13 to $+0.75$ D), the mean spherical refraction was 0.08 ± 0.31 D (from -1.00 D to $+1.00$ D), and the mean cylinder was -0.21 ± 0.27 D (from 0 to -1.00 D). For the RK group (Figure 1B), 18 eyes (81.82%) were within ± 0.50 D and 22 (100%) were within ± 1.00 D. The mean SE obtained was -0.17 ± 0.38 D (from -0.75 to $+0.38$ D), the average spherical refraction was 0.06 ± 0.43 D (from -0.75 D to $+1.00$ D), and the average cylinder was -0.45 ± 0.39 D (from 0 to -1.25 D). Specifically, for astigmatism, Figure 1C depicts the distribution of the refractive cylinder for the LASIK/PRK group. It shows 91.18% of the eyes ($n = 93$) with ≤ 0.50 D, and all of them ($n = 102$) with ≤ 1.00 D. It is interesting to point out that 74.51% ($n = 76$) of the eyes showed a cylinder ≤ 0.25 D. Figure 1D shows the distribution for the RK group where 68.18% of the eyes ($n = 15$) with ≤ 0.50 D, and 95.45% of eyes ($n = 21$) with ≤ 1.00 D. 45.45% of eyes ($n = 10$) showed a value ≤ 0.25 D. Figure 2 shows the

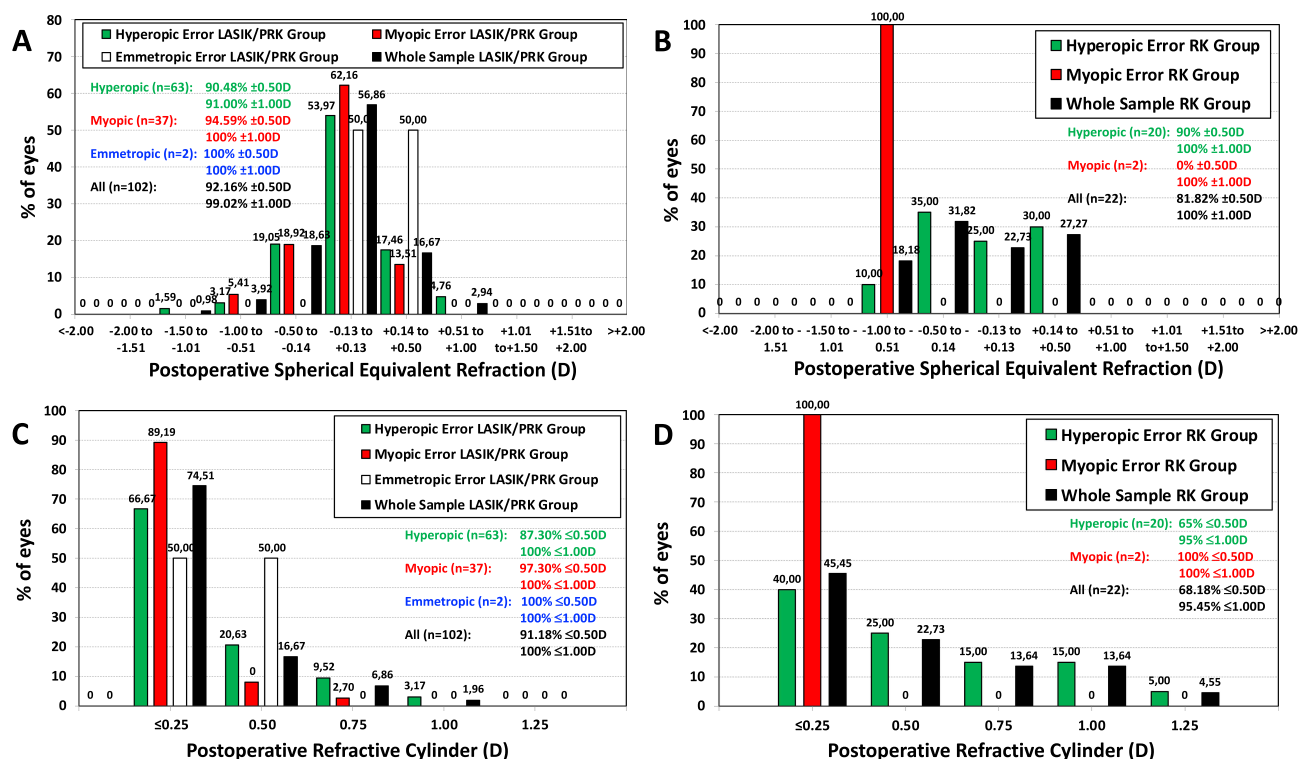


Figure 1 Distribution of postoperative spherical equivalent refraction 12 months after FineVision intraocular lens implantation in the LASIK/PRK (A) and RK (B) groups, and distribution of postoperative refractive cylinder 12 months after FineVision intraocular lenses implantation in the LASIK/PRK (C) and RK (D) groups. Outcomes are shown for the whole sample (black bars) and also as a function of the refractive error before intraocular lens implantation (green, red and white bars).

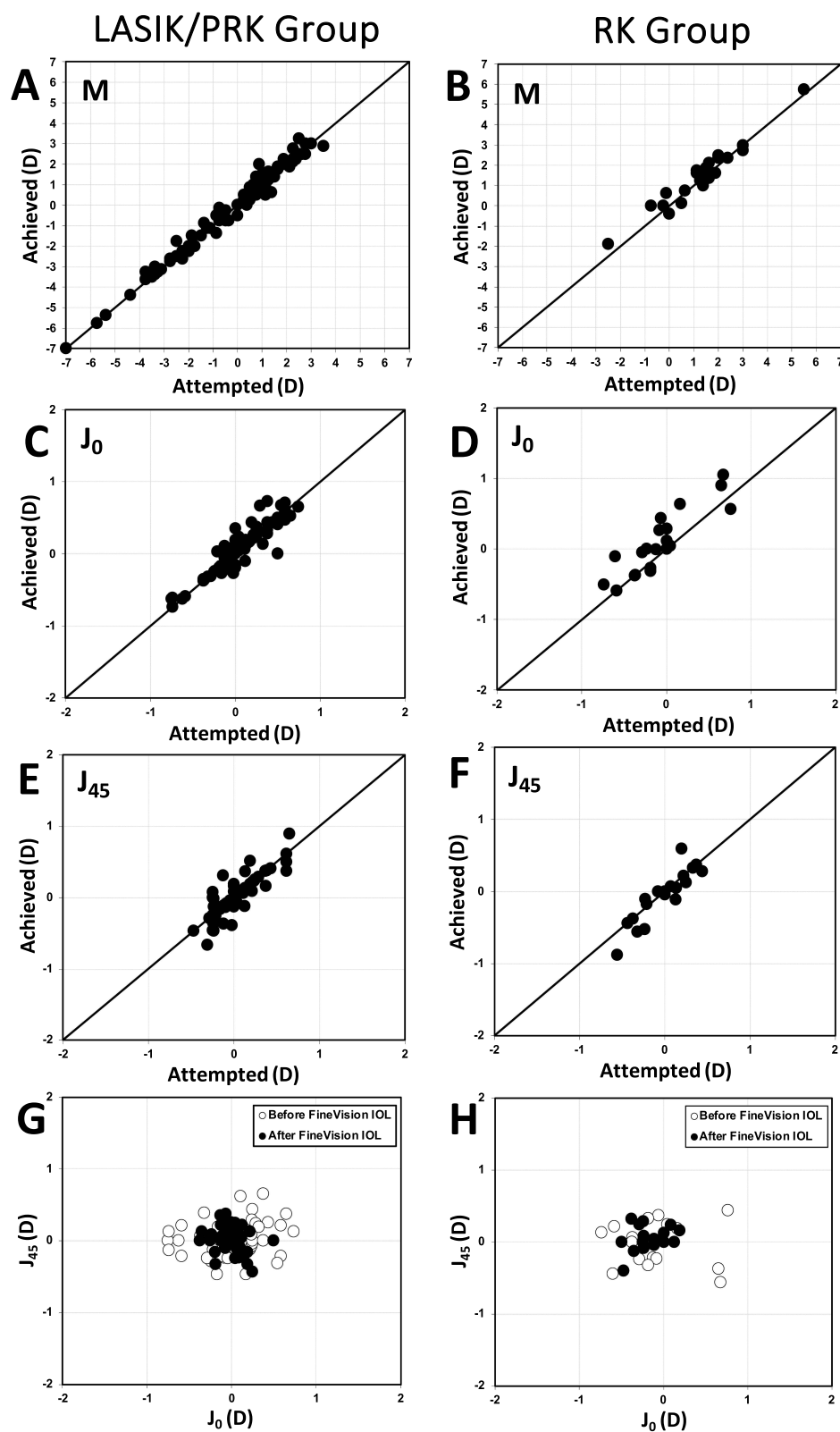


Figure 2 Attempted versus achieved spherical equivalent (M) (**A** and **B**) and the astigmatic J₀ (**C** and **D**) and J₄₅ (**E** and **F**) components of the power vector analysis after one year after surgery (**G** and **H**) in the LASIK/PRK and RK groups. Representation of the astigmatic vector (J₀ and J₄₅) before and one year after surgery (**D**). The scatterplot for J₀ and J₄₅ was calculated using the preoperative and postoperative refractive cylinder. Note that the coordinates 0:0 represent an eye free of astigmatism.

attempted versus achieved graphs for SE (A, B) and for the J_0 (C, D) and J_{45} (E, F) vectors of astigmatism in both groups. This figure also shows the astigmatic vectors before and 1 year after the surgery (G, H).

Visual Outcomes

The mean postoperative monocular decimal UDVA, CDVA and UNVA were 1.04 ± 0.19 , 1.14 ± 0.20 and 0.99 ± 0.04 , respectively, for the LASIK/PRK group. These values changed to 0.90 ± 0.10 , 1.01 ± 0.08 and 1.00 ± 0.00 , respectively, for the RK group. Figure 3 depicts the difference in monocular UDVA and CDVA after the surgery in both groups; 59.80% of the eyes ($n = 61$) showed a UDVA that was $\geq$ CDVA, and 65.69% ($n = 67$) of the eyes had an UDVA within

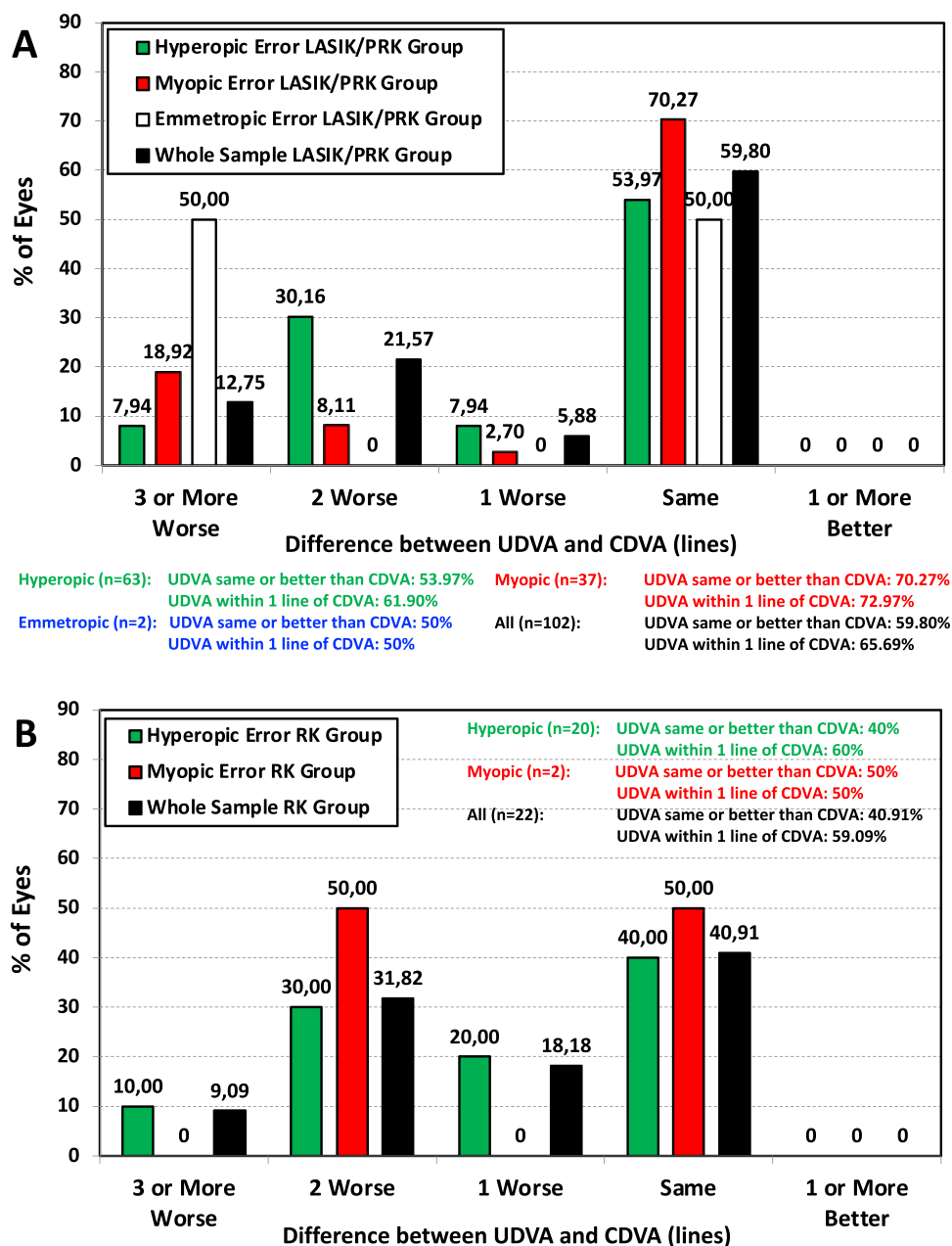


Figure 3 Difference in monocular uncorrected distance visual acuity (UDVA) and best corrected distance visual acuity (CDVA) 12 month after FineVision intraocular lens implantation in the LASIK/PRK (A) and RK (B) groups. Outcomes are shown for the whole sample (black bars) and also as a function of the refractive error before intraocular lens implantation (green, red and white bars).

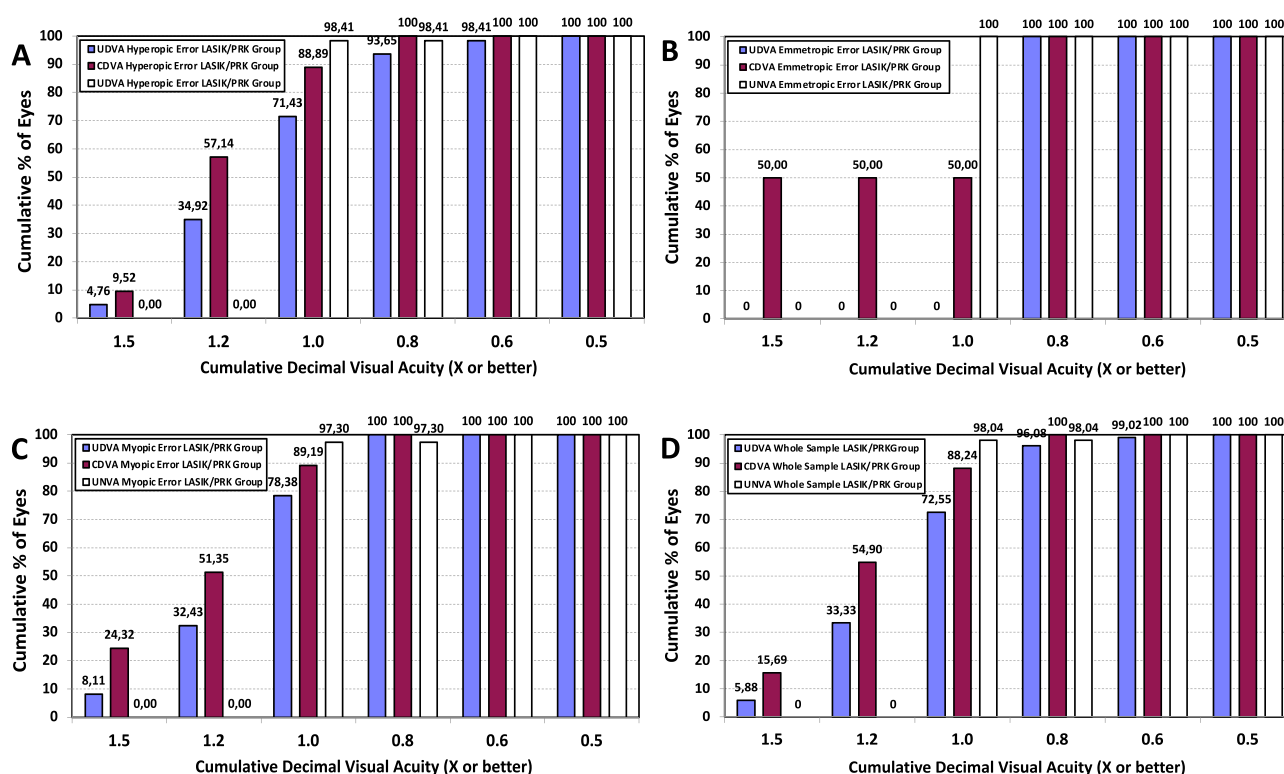


Figure 4 Cumulative proportion of eyes 12 months after FineVision intraocular lens implantation in the LASIK/PRK group with a given postoperative uncorrected and distance corrected visual acuity (UDVA and CDVA), and uncorrected near visual acuity (UNVA) at 40 cm. Outcomes are shown for the whole sample (D) and also as a function of the refractive error before intraocular lens implantation ((A): hyperopic, (B): emmetropic and (C): myopic).

one line of the CDVA for the LASIK/PRK group. These values were 40.91% ($n = 9$) and 59.09% ($n = 13$) respectively for the RK group.

Figure 4 depicts the cumulative percentage of eyes with a given UDVA, CDVA and UNVA in the LASIK/PRK group 12 months after the surgery. For the whole sample, 72.55% ($n = 74$), 88.24% ($n = 90$), and 98.04% ($n = 100$) of the eyes had $\geq 20/20$ UDVA, CDVA and UNVA, respectively, with 96.08% ($n = 98$), 100% ($n = 102$) and 98.04% ($n = 100$) of the eyes achieving $\geq 20/25$ for UDVA, CDVA and UNVA, respectively. Figure 5 illustrates the cumulative percentage of eyes with a given postoperative UDVA, CDVA and UNVA in the RK group 12 months after the surgery. For the whole sample, 45.55% ($n = 10$), 83.36% ($n = 19$), and 100% ($n = 22$) of the eyes had $\geq 20/20$ UDVA, CDVA and UNVA, respectively, with 90.91% ($n = 20$), 100% ($n = 22$) and 100% ($n = 22$) of the eyes achieving $\geq 20/25$ for UDVA, CDVA and UNVA, respectively.

Discussion

Due to the increasing demand from LCRS or RK patients to continue to be spectacle independent, whether they are affected by presbyopia or cataract, clinical investigations are required to provide surgical evidence of the use of trifocal IOLs when performing RLE or cataract surgery. It should be considered that the refractive accuracy after trifocal IOL implantation in LCRS or RK patients is very important due to a high expectation of spectacle independence after the surgery. Our study shows the clinical outcomes obtained in a cohort of eyes with previous LCRS or RK implanted with trifocal diffractive IOLs. The outcomes we have obtained demonstrate that the FineVision IOLs provide good vision at different distances with excellent refractive accuracy.

Trifocal IOL Implantation After LASIK/PRK

Specifically, we have found excellent refractive error accuracy after IOL implantation using essentially the ASCRS calculator. Note that 92.16% of eyes were within ± 0.50 D and 99.02% of eyes were within ± 1.00 D (see Figure 1A, being

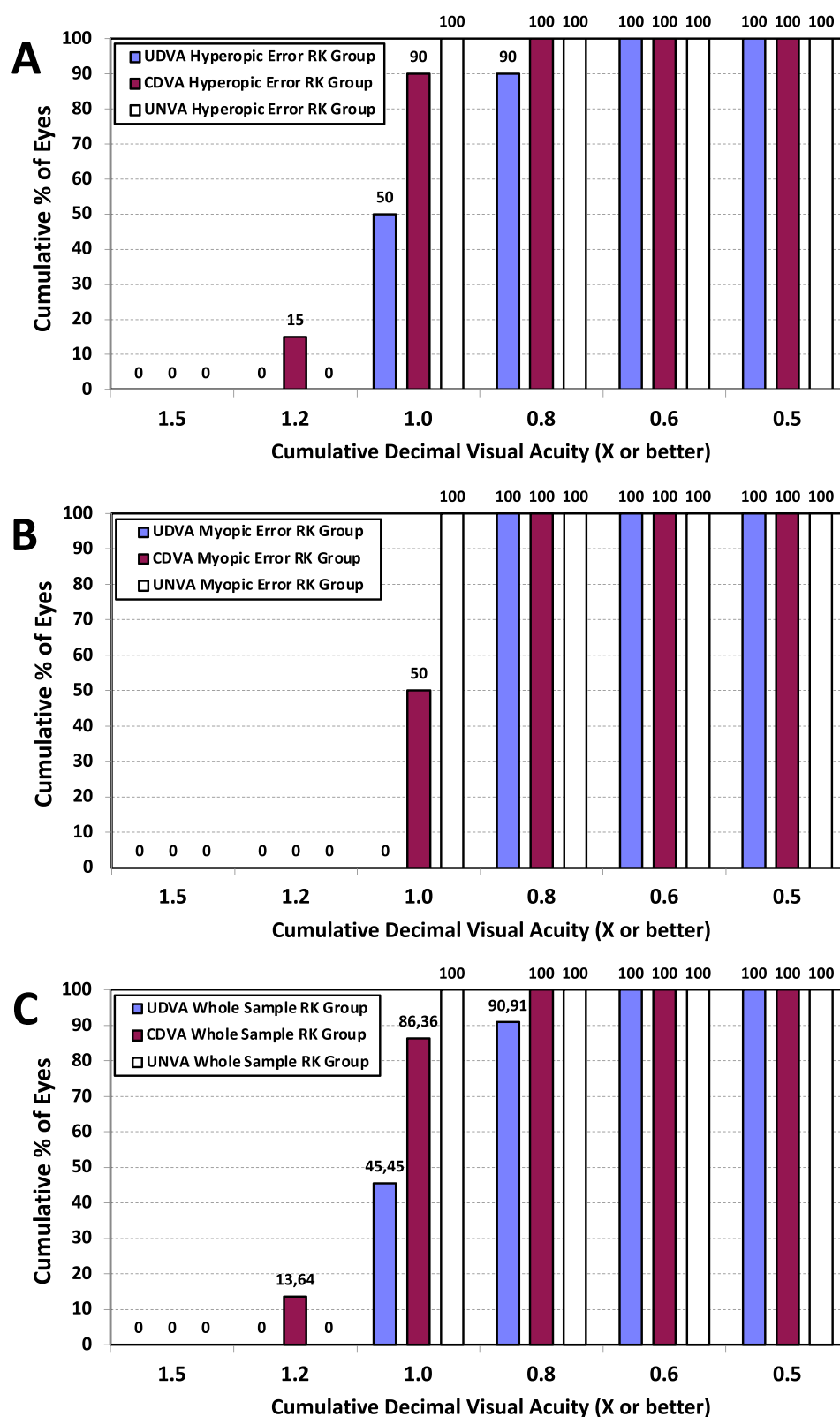


Figure 5 Cumulative proportion of eyes 12 months after FineVision intraocular lens implantation in the RK group with a given postoperative uncorrected and distance corrected visual acuity (UDVA and CDVA), and uncorrected near visual acuity (UNVA) at 40 cm. Outcomes are shown for the whole sample (**C**) and also as a function of the refractive error before intraocular lens implantation ((**A**): hyperopic and (**B**) myopic).

the postoperative mean SE close to emmetropia ($-0.03 \pm 0.30D$) and a mean cylinder of $-0.21 \pm 0.27D$, with 91.18% of eyes $\leq 0.50D$: Figure 1C). The attempted versus achieved plots also revealed the good outcomes obtained (Figure 2). Note that the coordinates 0:0 represent an eye without astigmatism (origin of the graph in Figure 2G) and, therefore, concentrated data about these coordinates after the surgery (black dots) indicate better correction of astigmatism. The accuracy of the surgeries correlates with the visual acuity outcomes, obtaining mean values $\geq 20/20$ at far and near with cumulative percentages for $\geq 20/25$ or better being close to 100% at all distances (see Figure 4).

As already mentioned, previous trials have published the outcomes of different trifocal IOL models in LCRS patients.^{9–16} Table 2 compiles the main characteristics of these publications. Brenner et al⁹ have used the same lenses as us, with a mean follow-up of 6.38 months in 155 myopic and 86 hyperopic ablation eyes after RLE surgery. They used the ASCRS calculator in some eyes and later an optimized nomogram. They found a mean post-surgery SE of $-0.25 \pm 0.38D$ and $-0.02 \pm 0.42D$ for the myopic and hyperopic ablation groups. 80% of eyes were $\pm 0.50D$ and 97.4% $\pm 1.00D$ for the myopic group and 82.6% $\pm 0.50D$ and 98.8% $\pm 1.00D$ for the hyperopic group. The numbers for the whole sample were 80.9% eyes $\pm 0.50D$ and 97.9% eyes $\pm 1.00D$ for the SE, and 51.4% of eyes within 0.25D and 80.0% of eyes within

Table 2 Clinical Studies Published Reporting Refractive and Visual Outcomes Following Trifocal Intraocular Lens (IOL) Implantation in Laser Corneal Refractive Surgery Eyes (LCRS)

Authors	Year	Sample (eyes)	LCRS Type	IOL Type (eyes)	Surgery	Follow-Up (Months)	IOL Formula Used
Brenner et al ⁹	2019	155 myopic 86 hyperopic	NR	FineVision Micro F FineVision POD F 195 non-toric 46 toric	RLE	6.38±5.88 (3–12)	ASCRS calculator (target 0.00D) Specific nomogram (target +0.25D)
Chow et al ¹⁰	2019	20 myopic	20 LASIK	AT LISA Tri 839 MP	Cataract	6	Holladay 2 (target -0.50 to $-1.00D$)
Li et al ¹¹	2020	21 myopic	14 LASIK 7 PRK	AT LISA Tri 839 MP	Cataract	3	Multi-formula average method of 4 formulas* (target 0.00D)
Cobo-Soriano et al ¹²	2021	319 myopic 549 hyperopic	842 LASIK 26 PRK	FineVision Micro F 210 myopic 330 hyperopic FineVision POD F 45 myopic 93 hyperopic AT LISA Tri 839 MP 64 myopic 126 hyperopic	RLE and Cataract	3	ASCRS calculator (target 0.00D)
Blaylock and Hall ¹³	2022	35 myopic	15 LASIK 20 PRK	AcrySof IQ PanOptix 10 non-toric 25 toric	RLE and Cataract	3	ASCRS calculator and Barrett True K for IOL power and Holladay 2 for toricity and intraoperative aberrometry
Mayordomo-Cerdá et al ¹⁴	2022	89 myopic 97 hyperopic	84 myopic LASIK 5 myopic LASEK 94 hyperopic LASIK 3 hyperopic LASEK	147 FineVision Micro F 79 myopic 68 hyperopic 39 AT LISA Tri 839 MP 10 myopic 29 hyperopic	RLE and Cataract	3	ASCRS calculator and Barrett True K (target 0.00D)
Mayordomo-Cerdá et al ¹⁵	2023	198 hyperopic	195 LASIK 3 PRK	120 FineVision POD F 78 RayOne Trifocal	RLE and Cataract	Mean 18 (0.2–56.4)	ASCRS calculator and Barrett True K (target 0.00D)
Bilbao-Calabuig et al ¹⁶	2024	211 myopic	211 LASIK	FineVision Micro F FineVision POD F	RLE and Cataract	Mean 5 (3–13)	ASCRS calculator, with the preferred formula and the searched refractive result selected by each surgeon in each case (target 0.00D).
Current study	2025	101	92 LASIK 10 PRK	FineVision Micro F FineVision POD F Toric	RLE and Cataract	12	Haigis, SRK-T and Hoffer Q (target 0.00D)

Note: *Haigis-L, Barrett Rue K, Shammas No-History and ray-tracing methods.

Abbreviations: NR, no reported; RLE, refractive lens exchange; LASIK, laser in situ keratomileusis; PRK, photorefractive keratectomy; LASEK, laser subepithelial keratomileusis; ASCRS, American Society of Cataract and Refractive Surgery.

0.50D for refractive astigmatism. For visual acuity outcomes, the mean UDVA (Snellen), CDVA (Snellen) and UNVA (point type) were 0.88 ± 0.20 , 1.06 ± 0.10 and 5.11 ± 0.46 , for the myopic group, respectively, and 0.85 ± 0.19 , 1.03 ± 0.10 , and 5.25 ± 0.75 for the hyperopic group, respectively. The entire cohort showed 47%, 81.3% and 98.8% of eyes with a cumulative UDVA $\geq 20/20$, $\geq 20/25$ and $\geq 20/20$, respectively. Of the eyes, 79.7% lost no lines of CDVA from the preoperative stage, 14.5% lost one line, 0.4% lost two lines, and 4.6% gained one line. The safety and efficacy indices found by these authors were 0.97 ± 0.08 and 0.80 ± 0.18 for the myopic eyes, and 0.98 ± 0.09 and 0.82 ± 0.17 for the hyperopic eyes. These authors also informed that 15% of eyes had refractive enhancement with 12% surface ablation and 3% with supplementary IOL after presbyopic RLE. They concluded that this procedure in LCRS eyes was safe and effective and that the ASCRS on-line-calculator was a valuable instrument for calculation of the IOL power. Our results broadly agree with them.

In another study, Chow et al¹⁰ and Li et al¹¹ analysed the performance of the AT LISA tri 839 MP IOL in a small sample of myopic eyes after cataract surgery, 20 and 21, respectively. Chow et al¹⁰ found a mean postoperative UDVA of 0.28 ± 0.29 logMAR, a mean CDVA of 0.06 ± 0.14 logMAR, and a mean UNVA of 0.02 ± 0.05 logMAR at 6 months. The mean SE was -0.92 ± 0.76 D with 55% of eyes achieving a SE ± 0.50 D of the targeted refraction (note that in this case it was -0.50 to -1.00 D in the preoperative stage by means of the Holladay 2 formula). Li et al¹¹ with a similar sample of myopic eyes but in a short follow-up (3 months) and using a multi-formula average method (Barrett True K, Haigis-L, ray-tracing and Shammas No-History, target emmetropia), obtained a mean SE of -0.56 ± 0.49 D (47.6% within ± 0.50 D and 90.5% within ± 1.00 D). For monocular conditions, they obtained average logMAR UDVA and UNVA of 0.02 ± 0.07 and 0.15 ± 0.11 , respectively. 100% of eyes achieved a postoperative CDVA $\geq 20/25$, while the percentage for a UDVA of $\geq 20/25$ was 76%. These authors are in agreement with the previous study.

Cobo-Soriano et al¹² analyzed the largest sample of myopic ($n = 319$) and hyperopic (549) eyes using the FineVision Micro F, FineVision POD F and AT LISA tri 839 MP IOLs at 3 months after the RLE or cataract surgeries using the ASCRS calculator with the target of emmetropia. Their results showed a postoperative mean SE of -0.38 ± 0.30 D and -0.17 ± 0.30 D for the myopic and hyperopic groups, respectively. 63.5% and 73.5% of eyes were within ± 0.50 D, respectively. In relation to visual acuities, monocular logMAR UDVA, CDVA and UNVA were 0.09 ± 0.08 , 0.03 ± 0.04 and 0.15 ± 0.14 for the myopic group, and 0.1 ± 0.08 , 0.06 ± 0.05 and 0.16 ± 0.12 for the hyperopic group, respectively. The outcomes reported by these authors disagree with those found by Brenner et al⁹ since Cobo-Soriano et al¹² show loss of CDVA and worse safety outcomes after the surgery in hyperopic eyes. They argued that these differences may come from the differences in the change in CDVA lines. Finally, they concluded that implantating this IOL was compatible with previous LCRS. We support their findings considering that the use of trifocal IOLs can be used in LCRS eyes.

Blaylock and Hall¹³ analyzed the outcomes using another trifocal model, the AcrySof IQ PanOptix IOL, in 25 myopic eyes (15 LASIK and 20 PRK) submitted to RLE and cataract surgeries at 3 months. They found a mean SE of 0.03 ± 0.45 D, with 76% of eyes within ± 0.50 D and 97% within ± 1.00 D of SE, and 91% and 100% of eyes with refractive astigmatism of ≤ 0.50 D and ≤ 1.00 D, respectively. In relation to visual acuity, 100% of eyes had monocular visual acuities of $\geq 20/40$ at all distances, with the percentage of eyes $\geq 20/20$ for UCVA, CDVA, and UNVA being 28.6%, 77.1%, and 65.6%, respectively. These values changed to 74.3%, 97.1% and 90.6% for $\geq 20/25$, respectively. The mean monocular UCVA, CDVA and UNVA were 0.09 ± 0.08 , 0.02 ± 0.05 and 0.05 ± 0.10 , logMAR respectively. These authors also analyzed the possible differences between preoperative planning or the use of intraoperative aberrometry, reporting no significant differences in the absolute prediction error ($P > 0.05$) but less postoperative residual astigmatism ($P < 0.002$).

Mayordomo-Cerdá et al¹⁴ assessed the outcomes using the Finevision Micro F and AT LISA 839 MP IOL in 89 myopic and 97 hyperopic eyes after LASIK and LASEK procedures. These eyes were submitted to RLE or cataract surgeries and evaluated at 3 months – using the ASCRS calculator with the Barrett True K for IOL power calculation with the target of emmetropia. Specifically, all the eyes analyzed in this study were submitted to an enhancement. The outcomes before the enhancement reported a mean SE of -0.93 ± 0.29 D and -0.69 ± 0.49 D in the myopic and hyperopic groups. The mean monocular UDVA, CDVA and UNVA were 0.31 ± 0.14 , 0.05 and 0.10 logMAR for the myopic group, and 0.28 ± 0.20 , 0.06 , and 0.18 logMAR for the hyperopic group, respectively. These authors also reported detailed outcomes of this cohort after the enhancement, with PRK (72.1%) or flap lift (28.0%). In another study, the same group of authors aimed to assess whether the use of the Rayone trifocal IOL (neutral spherical aberration) provided better

outcomes than the FineVision POD F IOL (negative spherical aberration) in 198 hyperopic eyes with previous LCRS after RLE or cataract surgeries. They used the ASCRS calculator with the Barrett True K for IOL power calculation with the target of emmetropia. One hundred and twenty eyes were implanted with the FineVision POD F IOL and 78 eyes with the RayOne IOL. After the surgery the average SE was $-0.01 \pm 0.38\text{D}$ for the FineVision POD F and $-0.34 \pm 0.51\text{D}$ for the RayOne IOL (the differences were significant, $P < 0.001$). However, no significant differences were found for visual acuities, with the monocular logMAR UDVA standing at 0.10 and 0.07 ($P = 0.647$), the monocular logMAR CDVA at 0.05 and 0.05 ($P = 0.343$), and the monocular UNVA at 0.18 and 0.18 ($P = 0.382$) for the FineVision POD F and RayOne IOLs, respectively.

Bilbao-Calabuig et al¹⁶ studied 211 myopic eyes previously submitted to LASIK surgery after the FineVision Micro F and POD F IOLs implantation. These authors also used the ASCRS calculator with the target refraction of emmetropia. After RLE or cataract surgeries, the average SE and cylinder were $-0.29 \pm 0.29\text{D}$ and $-0.30 \pm 0.31\text{D}$, respectively (65% of eyes within $\pm 0.50\text{D}$ and 87% within $\pm 1.00\text{D}$ from emmetropia). The average monocular logMAR UDVA, CDVA and UNVA were 0.09 ± 0.07 , 0.04 ± 0.04 and 0.14 ± 0.07 , respectively. The corneal laser enhancement after RLE or cataract surgeries was 15.7%.

Our outcomes are in agreement with other clinical studies, using the Finevision lens and other models, and support the use of these lenses in LCRS eyes when performing cataract or RLE surgeries in order to avoid the use of glasses for any distance.

Trifocal IOL Implantation After RK

Focusing now on the RK group refractive accuracy – despite the fact that we as well used the ASCRS calculator to calculate the IOL power – our results were not so good as those obtained in the LASIK/PRK group. This is probably bound to the corneal irregularity created by the incisions and, consequently, the higher optical aberrations that affect the eye after the procedure. In our sample, 81.82% eyes were within $\pm 0.50\text{D}$ and 100% were within $\pm 1.00\text{D}$ (Figure 1B), with the mean SE of $-0.17 \pm 0.38\text{D}$ but the mean refractive cylinder close to a half diopter ($-0.45 \pm 0.39\text{D}$). Note that only 68.18% of the eyes showed residual astigmatism of $\leq 0.50\text{D}$ (Figure 1D). These seem not to affect the visual acuity outcomes since the mean UDVA, CDVA and UNVA were close to 20/20 and 90.91%, and 100% of eyes achieved $\geq 20/25$ or better for UDVA, CDVA and UNVA, respectively (Figure 5C).

As we mentioned at the beginning of this article, previous publications have shown the performance of different presbyopia-correcting IOLs in RK eyes.^{19–23} Table 3 illustrates the main characteristics of these publications indicating the type of IOL implanted. Gupta et al¹⁹ showed the results for two eyes with the bifocal AcrySof IQ ReSTOR IOLs (two

Table 3 Clinical Studies Published Reporting Refractive and Visual Outcomes Following Presbyopia-Correcting Intraocular Lens (IOL) Implantation in Radial Keratotomy Eyes

Authors	Year	Sample (Eyes)	IOL Type	Surgery	Follow-Up (Months)	IOL Formula Used
Gupta et al ¹⁹	2014	2	AcrySof IQ ReSTOR and Tecnis	Cataract surgery with monovision (multifocal IOL in non-dominant eye and monofocal IOL in dominant eye). Bilateral RK (cuts: 8/12)	3	Holladay I (axial length between 21 and 26 mm) SRK-T (axial length >26 mm)
Kim et al ²⁰	2017	2	Oculentis LS313-MF30	RLE surgery Unilateral RK (cuts: 8/8)	6-3	Aramberri double-K
Nuzzi et al ²¹	2017	1	Soleko FIL611PVT toric	Cataract surgery with toric multifocal with previous cross-linking Bilateral RK (cuts: 16/16)	13	Holladay I and SRK-T

(Continued)

Table 3 (Continued).

Authors	Year	Sample (Eyes)	IOL Type	Surgery	Follow-Up (Months)	IOL Formula Used
Martin-Escuer et al ²²	2019	17	Symfony ZXROO, AcrySof ReSTOR (SN6ADI and SN60D3), Tecnis ZMBOO, FineVision, Acri. LISA 366D and AT LISA tri 839MP	Cataract or RLE surgery Unilateral or bilateral RK (cuts: from 4 to 16)	6	Aramberri double-K (target: $-1.00D$)
Agarwal and Thornell ²³	2020	5	IC-8 AT LISA 939M toric	Cataract surgery Bilateral RK and LASIK	NR	Barrett True-K (target $-0.75D$ for IC-8 IOL, and between 0 and $\pm 0.50D$ for trifocal IOL)
Current study	2025	22	FineVision Micro F FineVision POD F Toric	RLE and Cataract	12	Haigis and SRK-T (target 0.00D)

Abbreviations: RK, radial keratotomy; RLE, refractive lens exchange; LASIK, laser in situ keratomileusis; NR, not reported.

patients with monovision), concluding that this procedure was a good solution for subjects aiming to be spectacle-free. Monocular CDVA was 20/20 in 3 eyes and distance corrected near visual acuity (DCNVA) was 20/20 in both patients.

Kim et al²⁰ concluded that the use of a rotationally asymmetric refractive multifocal lens (2 eyes from 2 unilateral RK subjects) may benefit presbyopic patients. They reported an UDVA of 20/20 and an UNVA of J1 for both patients.

And Nuzzi et al²¹ considered that the implantation of a customized-toric multifocal lens in an eye with previous cross-linking leads to good visual outcomes without regressions.

In contrast to these studies, Martin-Escuer et al²² concluded that the use of a multifocal lens in RK eyes did not result in good distance visual performance. They reported the outcomes using different presbyopia-correcting IOLs in a sample of 17 eyes. The UDVA, DCVA, and DCNVA for monocular conditions were 0.51 ± 0.39 , 0.20 ± 0.30 , and 0.11 ± 0.11 logMAR, respectively. 35.29% of the eyes had DCVA of $\geq 20/20$ and 52.94% showed DCVA of $\geq 20/25$. 52.94% lost 1-line of DCVA, 23.53% showed no changes, 11.76% gained 1-line of DCVA, 5.88% gained 2-lines, and 5.88% gained ≥ 3 -lines. 29.41% of the eyes had DCNVA of $\geq 20/20$ and 64.71% had DCNVA of $\geq 20/25$. 29% of the eyes were within $\pm 0.50D$, whereas 65% were within $\pm 1.00D$.

This study and the current one are the only two studies that have been published to date that use trifocal IOLs in RK eyes, and our results support the use of the FineVision model in these eyes. Note that the number of RK cuts, formula and target refraction may affect the procedure and hence the outcomes obtained.

In another study, Agarwal and Thornell²³ assessed spectacle independence in 3 patients with RK implanted unilaterally with the IC-8 IOL pinhole, and one patient with RK and LASIK with bilateral use of the AT LISA 939M toric IOL, and concluded that both lenses offer satisfactory outcomes reducing the use of spectacles.

It should be considered that the corneal surface in these eyes is altered, showing irregularities that increase optical aberrations²⁶ by creating a “multifocal lens effect”²⁷ and when this is combined with diffractive IOL designs, the visual performance may be reduced. Also, the central corneal flattening with irregularities created by the radial incisions and diurnal variations over time²⁸ make it difficult to obtain accurate keratometric measurements. These factors may play a considerable role when the IOL power is calculated and therefore affect the accuracy of the procedure and the visual outcomes obtained. Note that residual refractive errors after this procedure can be corrected with corneal topography-guided laser treatments and that may improve the optical quality and contrast sensitivity function²⁹ in these eyes.^{30,31} Possibly, the combination of several corneal treatments with diffractive IOLs may reduce visual performance under low-light conditions.³²

Capsulotomy

In relation to Nd:YAG laser capsulotomy, only 2 studies of the same group reported their outcomes. Cobo-Soriano et al¹² reported this procedure in 21% of hyperopes and 13.7% in the myopes with the 3 types of IOL implanted. In relation to

the IOL type, they reported that the AT LISA tri 839MP lens had a higher rate of capsulotomies (37%) compared to the Finevision Micro F (11%) and POD F (20%) lenses. Notwithstanding, the time from IOL surgery to the capsulotomy was shorter in both Finevision lenses compared to that in the AT LISA lens (14 versus 24 months). The percentages found are in agreement with those previously reported showing higher values with the AT LISA tri 839MP lens than those found by the Finevision lenses.³³ Mayordomo-Cerdá et al¹⁴ reported similar percentages, begin 16.5% in the hyperopes and 9.0% in the myopes for the Finevision Micro F and AT LISA tri 839 MP models. Our results indicated that Nd:YAG laser capsulotomy was carried out in 2.94% of eyes (n = 3).

Conclusion

The present study demonstrated that use of a diffractive trifocal lens can provide good clinical outcomes in eyes previously submitted to LCRS or RK. The use of this type of IOLs is a reasonable choice in our patients.

Disclosure

The authors report no conflicts of interest in this work.

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