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Multifocal Intraocular Lens Results in Correcting Presbyopia in Eyes After Radial Keratotomy

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Objectives: To report results of multifocal intraocular lens (IOL) implantation in 2 patients with refractive error and presbyopia after previous radial keratotomy (RK).

Methods: A refractive multifocal IOL with rotational asymmetry (LS313-MF30; Oculentis, Berlin, Germany) was implanted.

Results: The first patient was a 60-year-old man with myopia who underwent unilateral RK 20 years before. His uncorrected distance visual acuity (UDVA) was 20/400, and his distance corrected near vision was J9 in both eyes. Six months after bilateral surgery, his binocular UDVA and uncorrected near visual acuity (UNVA) improved to 20/20 and J1, respectively, although he experienced diurnal fluctuation. The second patient was a 55-year-old woman with hyperopia who underwent bilateral RK 18 years before. Uncorrected distance visual acuity was 20/25 in both eyes, but UNVA was between J9 and J10. Three months after unilateral surgery, UDVA and UNVA of the postsurgical eye improved to 20/20 and J1, respectively. Neither patient reported any significant photic phenomena, and both were satisfied with the results of treatment.

Conclusions: The desirable clinical outcomes and levels of satisfaction expressed by these patients indicate that surgery using this particular multifocal IOL may benefit presbyopic patients with previous RK.

Key Words: Intraocular lens—Multifocal—Refractive lens exchange—Presbyopia—Radial keratotomy.

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Radial keratotomy (RK) was introduced in the 1970s and remained the most widely performed refractive surgical procedure until it was replaced by excimer laser technology in the 1990s. Many patients who underwent RK, however, experienced a variety of sequelae, including overcorrection or undercorrection, unstable vision, and hyperopic or myopic shift.[1,2] Furthermore, as these patients have aged, many have experienced cataracts and presbyopia. The inability to predict refractive outcomes of cataract surgery in these patients has prevented the implantation of multifocal intraocular lenses (IOLs).[3,4] To date, therefore, there have been no descriptions of multifocal IOL implantation in patients who previously underwent RK.

We report 2 post-RK patients who underwent refractive lens exchange using multifocal IOLs to treat refractive error and presbyopia. One experienced compound myopic astigmatism and the other experienced compound hyperopic astigmatism. Neither patient reported any significant photic phenomena. Moreover, both patients were satisfied with the results of treatment, despite 1 patient experiencing diurnal fluctuation in vision and the other having corneal topographical irregularity.

REPORT OF CASES

Patient 1

A 60-year-old man presented with progressive visual discomfort and contact lens (CL) intolerance in both eyes. Twenty years before, he underwent RK in his left eye at another hospital, but, being dissatisfied with the surgical results, he did not undergo RK on his right eye. Almost immediately after RK, he started using CLs in both eyes, with the power adjusted to provide monovision; the power of the lenses was changed several times in subsequent years according to the progressive change in refractive error.

Corrected distance visual acuity (CDVA) was 20/30 in his right eye and 20/25 in his left eye, with refractions of −3.75−1.00×100 and −6.25−1.25×165, respectively. Uncorrected distance visual acuity (UDVA) was 20/400 in both eyes. The CL power was −3.00 in both eyes. His CL-corrected binocular distance vision was 20/30, and his CL-corrected binocular near vision (40 cm) was J9. Slit-lamp examination revealed 8 well-healed RK scars in his left eye but no visually significant lens opacities in both eyes. Corneal astigmatism was observed in the left eye using topography (Pentacam; Oculus, Wetzlar, Germany) (Figs. 1A, B). After confirming stable refraction with discontinuation of CL wear for 3 weeks, refractive lens exchange was performed using multifocal IOLs to correct myopia and presbyopia in both eyes.

The American Society of Cataract and Refractive Surgery (ASCRS) IOL calculator for eyes with previous RK was used to calculate the IOL power in his left eye.[3] This calculator used the average central corneal power method and the Aramberri double-K modification of the Holladay 1 formula, with the data obtained by topography (Pentacam) and interferometry (IOLMaster; Carl Zeiss

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Patients have consented to submission of this case report to the journal.

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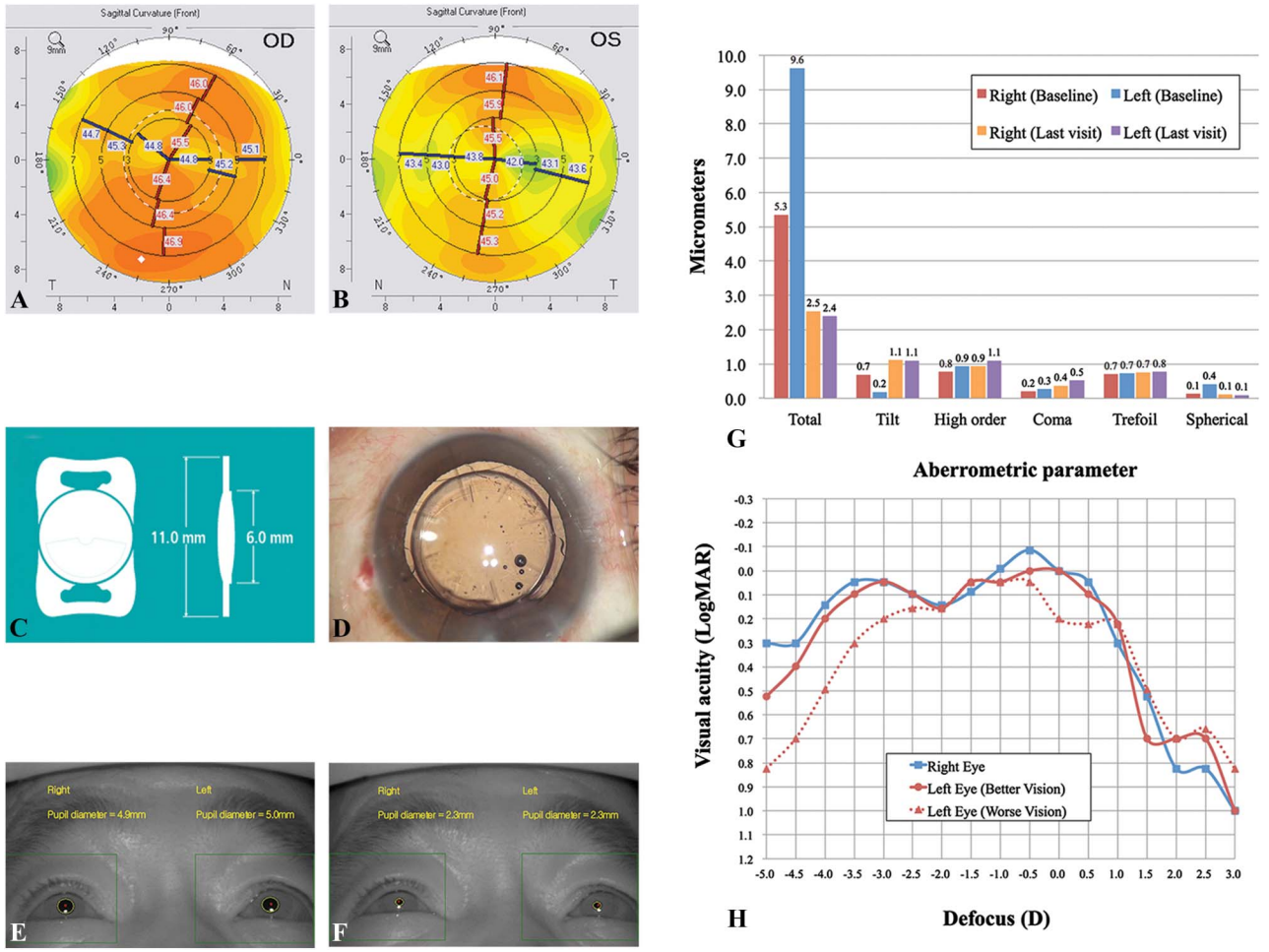

FIG. 1. Clinical data from patient 1. A and B, Corneal astigmatism was more prominent in the left eye (B) than in the right eye (A). C and D, A refractive multifocal intraocular lens with a rotationally asymmetric design (C) was used and implanted uneventfully by a temporal clear corneal incision in the left eye (D), and the same procedure was performed in the right eye after 1 week. E and F, Pupil size was not different between both eyes under (E) scotopic and (F) photopic conditions. G, Amount of postoperative aberration was not different between the two eyes with no notable increase from the baseline. H, Defocus curve results 6 months postoperatively reveal that vision at all distances for daily life activities was 20/40 or better in the left eye, although he experienced diurnal fluctuation.

Meditec, Jena, Germany). The results of the study that evaluated the ASCRS calculator[3] led to selecting an IOL targeting emmetropia by adding 1.0 diopter (D) to the predicted power. Power calculation for the right eye was performed using the SRK/T formula, and data that included corneal refractive power and axial length obtained from interferometry (IOL master). Surgery on both eyes was performed using the same procedure at an interval of 1 week and was uneventful. A refractive multifocal IOL with rotational asymmetry (LS313-MF30; Oculentis, Berlin, Germany) was implanted into the capsular bag of each eye using a 2.2-mm temporal clear corneal incision (Figs. 1C, D).

Beginning on the first postoperative day, the right eye showed stable postoperative uncorrected distance and near vision, at levels of 20/20 and J1, respectively. In contrast, the left eye showed fluctuations in UDVA, from 20/32 to 20/20, and in uncorrected near visual acuity (UNVA), from J3 to J1, during the entire follow-up period, with a corresponding change in refraction from −0.50 −1.50×170 to +0.50 −1.50×170. The patient also reported diurnal variation in vision of his left eye, which was perceived only by intentional occlusion of the right eye during self-examination. A defocus curve was obtained at several follow-up visits to measure the diurnal variation in vision. At the last follow-up, 6 months after surgery, UDVA was 20/20 in the right eye and 20/32 in the left eye, and UNVA was J1 and J3, respectively; however, binocular UDVA and UNVA reached 20/20 and J1, respectively. Subjective refraction was 0.00 −0.50×150 in the right eye and −0.25 −1.50×170 in the left eye. Pupillometry (MonCV3; MetroVision, France) and ocular aberration tests (OPD scan II; Nidek, Aichi, Japan) were performed and a defocus curve obtained at the last follow-up (Figs. 1E, H). The patient was satisfied and spectacle independent for daily life activities, and he did not report any significant photic phenomena on a quality-of-vision questionnaire (Table 1).[5]

Patient 2

A 55-year-old woman visited our clinic with difficulty viewing near objects bilaterally. She had undergone bilateral RK 18 years

TABLE 1. *Postoperative Scores for Visual Disturbances, Lifestyle Activities, Spectacle Use, and Overall Satisfaction, as Obtained by Questionnaires*

Item	Score[a]	
	Patient 1	Patient 2
Visual disturbances (from 0 to 5)		
Glare	1	1
Halo	2	1
Double vision	0	0
Night vision	0	0
Visual lifestyle activities (from 0 to 5)		
Watching television	0	0
Driving at night	3	1
Using a computer	0	1
Reading	0	0
Using a cell phone	0	0
Shaving/applying makeup	0	0
Spectacle use (from 0 to 3)		
For distance vision	0	0
For intermediate vision	0	0
For near vision	0	0
Overall satisfaction (from 0 to 10)	8	10

[a]Response rating scales for visual disturbance and lifestyle activities: 0 = no difficulty, 1 = minimal difficulty, 2 and 3 = moderate difficulty, and 4 and 5 = severe difficulty; for spectacle use: 0 = never, 1 = rarely or occasionally, 2 = often, and 3 = always; for overall satisfaction: range from 0 (least satisfied) to 10 (most satisfied).

before in another hospital. Uncorrected distance visual acuity was 20/25 in both eyes, but UNVA (40 cm) was J9 in her right eye and J10 in her left eye. Refraction was +1.50 −0.50×50 in her right eye and +2.25 −1.25×130 in her left eye, and CDVA was 20/16 and 20/20, respectively. Slit-lamp examination showed 8 well-healed RK scars in each eye, with no visually significant lens opacities. Corneal topography using Pentacam revealed central flattening with irregularity in the left eye, but less irregularity in the right eye (Figs. 2A, B). Because of her strong demand to perform close-up work without glasses, she was scheduled to undergo refractive lens exchange using a multifocal IOL to correct hyperopia and presbyopia in the left eye, in which near vision was poorer.

The IOL power in her left eye was calculated, and the same method of surgery, including the same type of IOL, was used for post-RK eyes as described for patient 1. Surgery on this patient was uneventful (Figs. 2C, B).

Postoperatively, UNVA in her left eye had improved to J1. At 3 months, the UDVA was 20/20 and subjective refraction was +0.25 −0.50×120 in her left eye. Her binocular UDVA was 20/20 and her UNVA was J1, with no fluctuations in vision. Pupillometry and tests of ocular aberration (iTrace, Tracey Technologies, Houston, TX) were performed and a defocus curve obtained at the last follow-up (Figs. 2E–H). The patient reported being spectacle independent for daily life activities, with no photic phenomena and a high level of satisfaction (Table 1).

DISCUSSION

Many techniques can be used to correct residual refractive error after RK; these include excimer laser techniques such as laser in situ keratomileusis and photorefractive keratectomy, and also phakic IOL implantation and CL.[6–9] However, these techniques cannot resolve presbyopia and cannot precisely predict the postoperative outcome; the optimal result they can achieve is monovision, which is not a complete resolution for presbyopia. Furthermore, IOL power calculation for cataract surgery after RK is difficult when performing refractive lens exchange with multifocal IOL.[3,4] To our knowledge, implantation of multifocal IOLs, especially those designed with the concept of rotational asymmetry, to simultaneously correct residual refractive error and presbyopia, has not been reported after RK. We believe that the findings presented here on bilateral multifocal IOL implantation after unilateral RK or vice versa in each of our patients provide useful information that could be used as a basis for further studies. Intraocular lens implantation in both patients improved both UDVA and UNVA significantly, to levels of 20/20 and J1, respectively, improvements likely due to the precise prediction by the ASCRS IOL calculator with adjustment. Therefore, this method is likely useful and easily accessible for determining IOL power after RK. In patient 1, the long-term use of monovision CLs may have beneficial effects on visual outcomes through quick adaptation despite residual astigmatism. Although many post-RK corneas, including those of patient 2, show topographic irregularities including multifocality, patient 1 experienced relatively regular astigmatism, which may have had positive effects on the results; however, a toric multifocal IOL may have been a more suitable option for this patient. Although concerns have been raised that multifocal IOL implantation after refractive surgery may increase high-order aberrations (HOAs),[10] HOA and pupil size results did not differ significantly in both eyes of each patient, suggesting that use of multifocal IOLs may benefit post-RK patients, despite the multifocal and irregular outcomes of their corneas. The implanted IOL had a rotationally asymmetric refractive design with a posterior sector-shaped near-vision segment. This refractive design with minimal interface and the limited zone of producing different focuses may cause a minimal aberration, minimizing the aberrational effects produced by the deformed cornea after RK. Considering both reduction in image contrast traded for 2 or more simultaneous focal points and further decrease in contrast sensitivity in proportion to the amount of corneal aberration, such as coma, spherical aberration, or first-order astigmatism, when implanting multifocal IOLs,[10] complicated elevation of many aberrations in cases with complex distortion of the cornea due to more than 8 RK incisions performed in our patients may produce different outcomes. Furthermore, consequences similar to ours may not be ensued from the implantation of multifocal IOLs other than that used in this report because the optical quality and visual outcomes could vary according to their designs. Both patients expressed high levels of satisfaction with their outcomes, despite patient 1 experiencing a degree of fluctuating vision, which may be due to the diurnal variation known to occur in patients with RK.[2] Although implantation of monofocal IOLs into patients with uncertain surgical outcome is generally believed safer, multifocal IOLs may also have advantages in patients who have undergone RK, in terms of stereopsis in all working distances. Indeed, there was no significant increase in HOA and fewer photic phenomena than generally expected. However, diurnal variation after RK is a concern, and patients should be counseled preoperatively about this possibility. The first case presented in this report, however, suggests that previous exposure to diurnal variation after RK and long-term use of CLs for monovision may have the beneficial effect of facilitating neural adaption. Enthusiasm to spectacle independence and characteristics of both patients

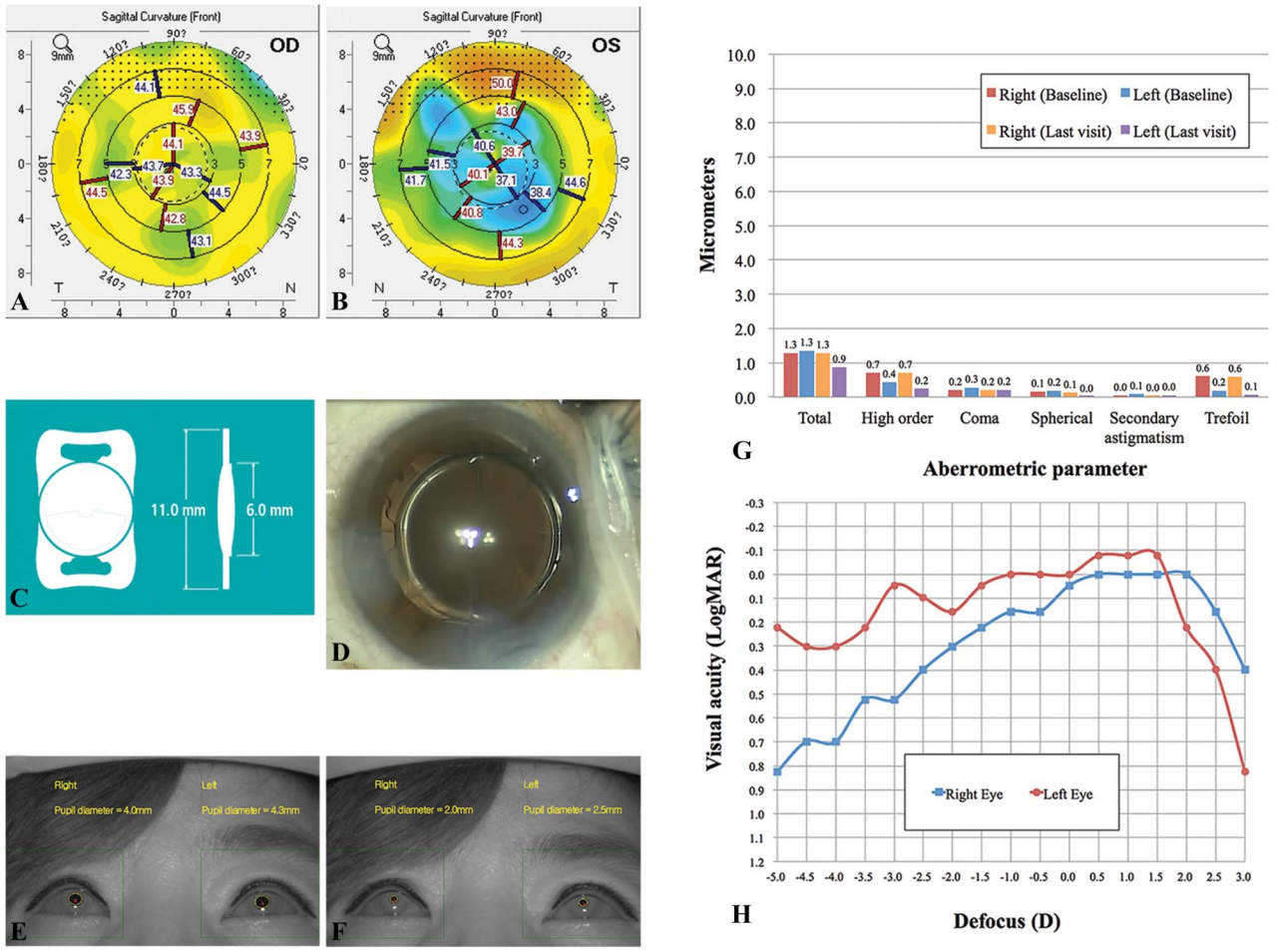

FIG. 2. Clinical data from patient 2. A and B, Corneal topography revealed central flattening with irregularity in the left eye (B), but less irregularity in the right eye (A). C and D, A refractive multifocal intraocular lens with a rotationally asymmetric design (C) was used and implanted uneventfully by a temporal clear corneal incision in the left eye (D). E and F, Pupil size was not different between both eyes under (E) scotopic and (F) photopic conditions. G, Amount of postoperative aberration was not increased after the surgery in the left eye. H, Defocus curve results at 3 months postoperatively.

in this report may be another factor for the gratification with their results of multifocal IOL implantation. Importance of careful selection of patients through preoperative evaluation and counseling should also not be overlooked for the success with multifocal IOLs even in post-RK patients.

In conclusion, implantation of multifocal IOL with rotationally asymmetric refractive design in our post-RK patients effectively corrected residual refractive error and presbyopia. The desirable clinical outcomes and levels of satisfaction expressed by these patients indicate that surgery using this particular multifocal IOL may benefit presbyopic patients with previous RK.

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