

# Clinical outcomes in a U.S. registration study of a new EDOF intraocular lens with a nondiffractive design



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**Purpose:** To evaluate the effectiveness and safety of the DFT015 intraocular lens (IOL) (AcrySof IQ Vivity Extended Vision) compared with an aspheric monofocal control IOL (AcrySof IQ model SN60WF).

**Setting:** 11 investigation sites in the U.S.

**Design:** Prospective randomized controlled clinical study.

**Methods:** Patients aged 22 years or older with bilateral cataracts were randomized to receive bilateral implantation of DFT015 or SN60WF. The 4 coprimary effectiveness outcomes (6 months postoperatively) were monocular photopic distance-corrected intermediate visual acuity (DCIVA), monocular photopic corrected distance visual acuity (CDVA), monocular depth of focus (DoF), and the percentage of patients achieving a DCIVA of 0.2 logMAR or better. The mean monocular photopic distance-corrected near visual acuity (DCNVA) was a secondary effectiveness outcome. Safety and patient-reported visual disturbances were evaluated through questionnaires.

**Results:** 218 patients (435 eyes) completed the study. Compared with SN60WF, DFT015 demonstrated superior mean monocular photopic DCIVA ( $P < .001$ ), noninferior mean monocular photopic CDVA, and superior mean monocular photopic DCNVA ( $P < .001$ ) and provided an extended monocular DoF (increase of 0.54 diopters at 0.2 logMAR). With DFT015, 78 first eyes (72.9%) achieved a DCIVA of 0.2 logMAR or better at 6 months. Incidences of ocular serious adverse events and patient-reported most bothersome visual disturbances were low and consistent between groups.

**Conclusions:** DFT015 is safe and effective for the visual correction of aphakia, exceeding American National Standards Institute criteria for an extended depth-of-focus IOL by providing superior DCIVA and DCNVA, with comparable CDVA and visual disturbances to the SN60WF monofocal IOL.

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Multifocal intraocular lenses (IOLs) are increasingly preferred during cataract removal surgery because of the convenience they provide to the daily life of the patient.<sup>1</sup> Unlike monofocal IOLs, multifocal IOLs use refractive or diffractive technology to create multiple foci, such as bifocal IOLs with distance and near focal points and trifocal IOLs with distance, intermediate, and near focal points.<sup>1–3</sup> However, the discrete focal points created by multifocal IOLs are also associated with photic phenomena (such as glare and halo) and reduced contrast sensitivity.<sup>3,4</sup> Therefore, there is an unmet need for an IOL that provides continuous vision across focal lengths (distance, intermediate, and near) while minimizing the issues with vision quality encountered with multifocal IOLs.<sup>3–5</sup>

To standardize IOL performances and improve patient outcomes, the American National Standards Institute (ANSI) has defined specific criteria for the minimum performance levels required to categorize a device as an extended depth-of-focus (EDOF) IOL (ANSI Z80.35-2018).<sup>6</sup> Requirements for effectiveness include (1) noninferior monocular mean corrected distance visual acuity (CDVA) compared with a monofocal IOL control; (2) a monocular DoF curve that demonstrates 0.50 diopters (D) or greater negative DoF compared with a monofocal IOL control at 0.2 logMAR (20/32 Snellen); (3) superior mean monocular distance-corrected intermediate visual acuity (DCIVA) at 66 cm under photopic conditions compared

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with a monofocal IOL control; and (4) at least 50% of eyes achieving a monocular DCIVA of 0.2 logMAR (20/32 Snellen) or better at 66 cm.<sup>6</sup> In addition, the ANSI recommends that any evaluations of EDOF IOLs include monocular mesopic contrast sensitivity function (eg, performed at spatial frequencies of 1.5, 3, 6, and 12 cycles per degree) and visual disturbances assessed using a patient-reported outcome measure.<sup>6</sup>

Currently available IOLs that claim to be EDOFs use a variety of technologies.<sup>4</sup> The Mini WELL Ready (Sifi Medtech Srl) extends the DoF by spherical aberration at the pupil's center while controlling higher-order aberrations at the pupil's periphery.<sup>7</sup> Small aperture IOLs, such as IC-8 (Acufocus, Inc.), use the pinhole effect to block unfocused paracentral light rays.<sup>4,8</sup> TECNIS Symphony (Johnson & Johnson Vision), a diffractive EDOF IOL, forms an echelette design that extends the range of vision.<sup>4,9</sup>

DFT015 (AcrySof IQ Vivity Extended Vision IOL, Alcon Laboratories, Inc.) is the first and only EDOF IOL with nondiffractive wavefront shaping (X-WAVE) technology.<sup>10,11</sup> This patented technology located on the anterior surface of the IOL achieves an extended range of vision using a next-generation optical principal, wavefront shaping, which differs from existing diffractive and refractive technologies' use to extend DoF. The DFT015 technology was designed to minimize distance quality issues and visual disturbances associated with multifocal IOLs, while providing improved intermediate and near vision compared with monofocal IOLs.<sup>11</sup> To achieve this, 2 smooth-surface transition elements are included on the anterior surface of the IOL to stretch and shift the wavefront rather than splitting light.<sup>10,11</sup> The first surface transition element is a slightly elevated smooth plateau (~1  $\mu\text{m}$ ) that delays a portion of the wavefront as it passes through the IOL (relative to the wavefront passing through the IOL outside of the transition element), causing the emerging wavefront to stretch forward and backward and creating a continuous extended focal range as it collapses down on the retina. The second transition element is a small change in the curvature that shifts the wavefront to the anterior side of the retina to use all the available light (Figure 1).<sup>12</sup> The simultaneous actions of the 2 surface transition elements deliver a naturally occurring extended focal range.<sup>12</sup> The surface profile of DFT015 is relatively flat and smooth and, to the naked eye, looks similar to that of SN60WF (AcrySof IQ monofocal IOL).<sup>10,11,13</sup> The anterior surface of DFT015 is also designed with negative spherical aberration to compensate for the positive spherical aberration of the cornea.<sup>10,11</sup>

As part of the clinical development program for DFT015, a prospective, multicenter, randomized controlled clinical study was conducted in the United States for purposes of U.S. registration. Herein, the results of this Investigational Device Exemption Study evaluating the safety and effectiveness of DFT015 compared with SN60WF 6 months after bilateral implantation are reported.

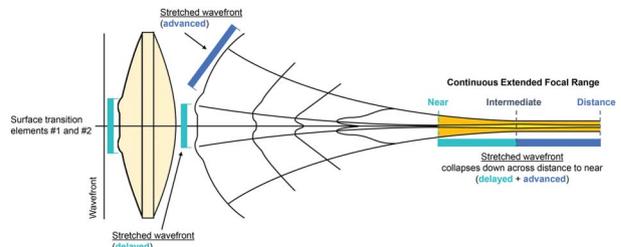


Figure 1. Illustration showing the mechanism of action of DFT015.<sup>9</sup>

## METHODS

### Study Design

This was a prospective, randomized, parallel-group, controlled, assessor- and patient-masked confirmatory study, conducted in multiple centers in the United States between October 2017 and October 2018 (ClinicalTrials.gov identifier NCT03274986). This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and the International Council for Harmonization of Technical Requirements for Pharmaceuticals for Human Use E6 Good Clinical Practice consolidated guideline, as well as ISO 11979-7, ISO 14155:2011, standard operating procedures of the study sponsor, and all other applicable regulations. Institutional review board approval was received for this study. The Chesapeake Institutional Review Board (Columbia, Maryland) was used for all 11 investigative sites.

### Patients

Patients eligible for inclusion in this study were adults (aged 22 years or older at the time of study enrollment) with bilateral cataracts who were scheduled for cataract removal through routine small-incision surgery and who had a preoperative CDVA of 0.3 logMAR (20/40 Snellen) or worse (with or without a glare source present), preoperative corneal astigmatism of <1.0 D in both eyes (as measured by keratometry), and a calculated lens power between 18.0 D and 25.0 D (when targeted for emmetropia, lens power implanted must have predicted manifest refraction spherical equivalent [MRSE] closest to 0 D).

Exclusion criteria included patients who had any disease or pathology (other than cataract) that was expected to reduce the potential CDVA to worse than 0.2 logMAR in the opinion of the study investigator, a history of recurrent anterior segment or posterior segment inflammation, any clinically significant corneal pathology or ocular surface disease that would adversely affect visual outcome or study measurements in the opinion of the study investigator, or a history of previous intraocular or corneal surgery or patients who desired monovision correction.

### Randomization and Assessments

Patients enrolled in the study were randomized to receive either bilateral DFT015 or bilateral SN60WF IOL implantation in a 1:1 ratio (Supplemental Figure 1, <http://links.lww.com/JRS/A601>). The first surgical eye was defined as the eye with the worse preoperative CDVA; if the CDVA was the same in both eyes, the right eye was defined as the first surgical eye. Implantation of the IOL in the second eye was required to occur within 14 days of the first-eye implantation. All eyes in the study were targeted to emmetropia (lens power chosen was closest to 0.00 D). The provisional SRK/T A-constant used in this study for model DFT015 was 119.1. The outer label of model SN60WF included a suggested A-constant as a guideline; however, it was recommended that the investigator uses their own appropriate constant based on clinical experience with model SN60WF. Most sites used

the provisional SRK/T with the Barrett formula, followed by the SRK/T formula.

Nine scheduled study visits were planned for each patient: screening, the 2 operative visits, and postoperative visits at days 1 to 2 (after each surgery), days 7 to 14 (after each surgery), days 30 to 60, and days 120 to 180. An electronic visual acuity system and electronic charts were used for all visual acuity and defocus testing (M&S Technologies, Inc.). Defocus curve testing was conducted monocularly and binocularly under photopic conditions at 4 m from the spectacle plane, using corrected distance refraction and added defocus, with visual acuity assessed between +1.50 D and -2.50 D in 0.5 D defocus steps, except in the region from +0.50 D to -0.50 D, which was assessed in 0.25 D steps. Photopic visual acuity assessment was also conducted monocularly and binocularly at 4 m, 66 cm, and 40 cm (distance corrected and uncorrected). Monocular contrast sensitivity was tested in mesopic conditions (with and without a glare source present) using a CSV-1000 HGT contrast sensitivity unit (Vectorvision, Inc.). Pupil size was measured with the NeuroOptics VIP-300 Pupillometer.

### End Points and Outcomes

The 4 coprimary effectiveness objectives of the study, developed in line with ANSI EDOF IOL criteria (ANSI Z80.35-2018), were to demonstrate that after 6 months, (1) DFT015 was superior to SN60WF regarding mean monocular photopic DCIVA, (2) DFT015 was noninferior to SN60WF regarding monocular photopic CDVA, (3) the monocular mean defocus curve for DFT015 had a negative range at least 0.5 D greater than SN60WF at 0.2 logMAR, and (4) that DFT015 resulted in at least 50% of eyes achieving a DCIVA of 0.2 logMAR or better.<sup>6</sup>

The 4 coprimary effectiveness end points (assessed at month 6) were the mean monocular photopic DCIVA at 66 cm from the spectacle plane, the mean monocular photopic CDVA at 4 m from the spectacle plane, the monocular DoF (measured in the negative direction from 0) at 0.2 logMAR, and the percentage of eyes achieving a monocular photopic DCIVA of 0.2 logMAR or better. Additional effectiveness end points (assessed at month 6) included the mean monocular photopic distance-corrected near visual acuity (DCNVA) at 40 cm from the spectacle plane, spectacle use as measured by the validated IOL Satisfaction questionnaire, binocular uncorrected distance visual acuity (UDVA), uncorrected intermediate visual acuity (UIVA), uncorrected near visual acuity (UNVA), CDVA, DCIVA, and DCNVA (including stratified by pupil size), as well as MRSE.

The 2 coprimary safety end points (assessed at month 6) were the rate of ocular adverse events (AEs; including visual disturbances) and the monocular mesopic contrast sensitivity, which was assessed at 1.5, 3, 6, and 12 cycles per degree (with and without a glare source present). The secondary safety end point was the rate of severe and most bothersome visual disturbances assessed at month 6 using the Questionnaire for Visual Disturbances (QUVID), which was developed and validated based on guidance from the U.S. Food and Drug Administration (FDA).<sup>11,14,15</sup>

### Statistical Analysis

All statistical analyses were performed using SAS software (v. 9.4, SAS Institute, Inc.). Sample size calculations led to a proposed study population of 220 randomized patients to ensure that 200 patients would complete the study (DFT015,  $n = 100$ ; SN60WF,  $n = 100$ ) and provide >99% power for the superiority hypothesis tests on mean monocular DCIVA (66 cm) and mean monocular DCNVA (40 cm) when tested at the 0.025 level of significance (1-sided), assuming that the difference in means was -0.12 logMAR (SD 0.18). The proposed sample size would also provide (1) 84% power for the noninferiority hypothesis with respect to mean monocular CDVA when tested at the 0.05 level of significance (1-

sided) and with a noninferiority margin of 0.10 logMAR, assuming that the difference in means was 0.04 logMAR (SD 0.16).

The primary analysis set for effectiveness end points was the all-implanted analysis set, defined as all randomized eyes that underwent successful IOL implantation. All safety end points used the safety analysis set, defined as all eyes with an attempted IOL implantation. For the primary statistical analyses, only the first implanted eye of each patient was included.

Specific testing parameters were used to evaluate the key effectiveness end points. The mean monocular photopic DCIVA and DCNVA superiority hypothesis tests (DFT015 vs SN60WF at month 6) and the mean monocular photopic CDVA noninferiority hypothesis test (DFT015 vs SN60WF at month 6) were conducted based on a fixed effects model with the main effect for treatment. Superiority was demonstrated if the 2-sided  $P$  value was <0.05. Noninferiority was demonstrated if the 1-sided 95% upper confidence limit was <0.1 logMAR. To account for multiplicity and maintain an overall type I error at the 0.05 level, a sequential testing approach was used in which statistical testing of 1 outcome (DFT015 vs SN60WF) was dependent on the rejection of the null hypothesis for the previous outcome in the hierarchy: (1) DCIVA (66 cm) superiority; (2) CDVA noninferiority; (3) DCNVA (40 cm) superiority; and (4) spectacle wear superiority. Data are presented as mean test vs control differences (ie, between DFT015 and SN60WF treatment groups) with associated 95% CIs and  $P$  values. For other end points, outcomes, and patient characteristics, numbers and percentages are presented for categorical variables, and descriptive statistics (ie, mean, median, SD, number of patients/eyes, minimum, maximum, and [2-sided] 95% CI) are presented for continuous variables. Treatment success for the third and fourth coprimary end points (monocular DoF and monocular photopic DCIVA responder rate) was defined as a 0.5 D greater negative range for DFT015 compared with SN60WF (at 0.2 logMAR) and >50% of eyes implanted with DFT015 achieving a DCIVA of 0.2 logMAR or better, respectively.

## RESULTS

### Patients

In total, 242 patients were enrolled in the study from 11 investigational sites. Of 242 patients, 221 were randomized to receive either DFT015 or SN60WF IOL implantation, 220 underwent the implantation procedure (DFT015,  $n = 107$ ; SN60WF,  $n = 113$  [all-implanted analysis set and safety analysis set, first eye]), and 218 completed the study (DFT015,  $n = 107$ ; SN60WF,  $n = 111$ ; Supplemental Figure 2, <http://links.lww.com/JRS/A601>). One patient in the DFT015 group underwent unilateral implantation; all other patients underwent bilateral implantation. Both patients who discontinued the study postoperatively received SN60WF implantation: 1 was lost to follow-up and 1 withdrew consent. Overall, patient demographics and baseline characteristics were similar between the 2 treatment groups (Table 1). The mean baseline monocular CDVA was worse than 0.2 logMAR in both groups, and the mean baseline corneal astigmatism was low (~0.5 D).

### Visual Outcomes

**Refractive Outcomes** At month 6, 98 first eyes (91.6%) implanted with DFT015 and 96 (86.5%) implanted with SN60WF achieved an MRSE within  $\pm 0.5$  D of emmetropia, with a mean  $\pm$  SD absolute MRSE of  $0.049 \pm 0.345$  D for the DFT015 group and  $0.081 \pm 0.411$  SD for the SN60WF group. No first eyes implanted with DFT015 presented with

**Table 1.** Patient demographics and baseline characteristics.

Parameter	DFT015 (n = 107)	SN60WF (n = 113)	Total (N = 220)
Age (y)			
<65	25 (23.4)	30 (26.5)	55 (25.0)
≥65	82 (76.6)	83 (73.5)	165 (75.0)
Mean (SD)	68.8 (7.82)	68.8 (6.63)	68.8 (7.22)
Female	59 (55.1)	64 (56.6)	123 (55.9)
Race			
White	105 (98.1)	110 (97.3)	215 (97.7)
Black/African American	1 (0.9)	1 (0.9)	2 (0.9)
Others	1 (0.9)	2 (1.8)	3 (1.4)
CDVA (logMAR), mean (SD)	0.230 (0.188)	0.243 (0.222)	0.237 (0.205)
AL (mm), mean (SD)	23.64 (0.77)	23.73 (0.72)	23.69 (0.74)
AL category			
Medium (21 to 26 mm)	107 (100)	113 (100)	220 (100)
ACD (mm), mean (SD)	3.25 (0.32)	3.21 (0.31)	3.23 (0.31)
Corneal astigmatism, mean (SD)	0.516 (0.245)	0.507 (0.269)	0.511 (0.257)

ACD = anterior chamber depth; AL = axial length

Data are presented as n (%), unless otherwise stated; CDVA, AL, AL category, and corneal astigmatism are for the first eye

an MRSE of >1.0 D at month 6, compared with 3 first eyes (2.7%) implanted with SN60WF.

**Copriary Effectiveness Outcomes** The 4 copriary effectiveness outcomes at month 6 are presented in Table 2. Compared with SN60WF, DFT015 implantation provided a statistically superior improvement in mean monocular photopic DCIVA (of approximately 1.6 lines), was shown to be noninferior regarding improvements in mean monocular photopic CDVA, and extended the monocular (first eye) negative DoF by ≥0.5 D. Similar results were also observed with binocular DoF (Figure 2).

**Monocular Near Visual Acuity** At month 6, DFT015 implantation provided superior mean photopic monocular DCNVA compared with SN60WF, with a between-group difference in the mean DCNVA of −0.156 logMAR (0.359 vs 0.515 logMAR, respectively; approximately 1.6 lines difference;  $P < .001$ ).

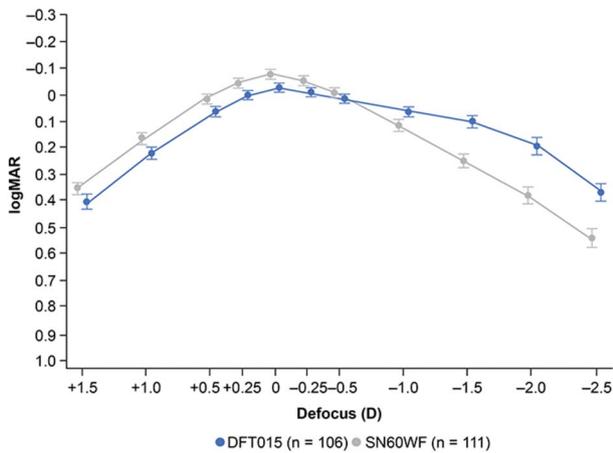
**Binocular Visual Acuity** Both DFT015 and SN60WF implantation groups achieved a mean binocular CDVA of <0.0 logMAR at month 6 with a <1-line difference between treatment groups, a >1-line difference in favor of DFT015 in mean binocular DCIVA, and a >1-line difference in favor of DFT015 in mean binocular DCNVA (Table 2). Similarly, the mean difference in binocular UDVA was <0.1 logMAR between groups at month 6, with an approximately 1-line between-group difference in favor of DFT015 in mean UIVA and a >1-line difference in favor of DFT015 in UNVA (Table 2). The UDVA, UIVA, and UNVA Snellen visual acuity equivalents of DFT015 (converted from logMAR using the closest category) were 20/20, 20/25, and 20/32, respectively. A Snellen notation of 20/20 −2 or better indicates a logMAR of 0.04 or better, which means patients correctly identified 3 or more of the 5 Early Treatment Diabetic Retinopathy Study chart letters on the line.

**Table 2.** Visual acuity outcomes at month 6.

Copriary effectiveness outcomes at month 6 (first eye; all-implanted analysis set)						
Parameter	DFT015 (n = 107)			SN60WF (n = 113)		Between-group difference
Monocular DCIVA <sup>a</sup>	0.148 (0.0120)			0.312 (0.0118)		−0.164 (0.0168) $P < .001$
Monocular CDVA <sup>a</sup>	0.016 (0.0091)			−0.036 (0.0089)		0.052 (0.0127) 95% UCL, 0.073
Monocular depth of focus at 0.2 logMAR (D)	1.53			0.99		0.54
Monocular DCIVA, n (%) 0.2 logMAR or better	78 (72.9)			28 (25.2)		NR
Binocular mean visual acuity at 6 mo (all-implanted analysis set)						
Parameter	DFT015 (n = 106)			SN60WF (n = 113)		
	n	Mean logMAR	SD	n	Mean logMAR	SD
CDVA	106	−0.028	0.084	111	−0.071	0.086
UDVA	106	0.035	0.102	111	−0.022	0.107
DCIVA	106	0.054	0.093	111	0.196	0.113
UIVA	106	0.058	0.083	111	0.139	0.122
DCNVA	106	0.253	0.118	111	0.391	0.135
UNVA	106	0.208	0.104	111	0.339	0.149

NR = not reported; UCL = upper confidence limit

<sup>a</sup>Least-squares mean logMAR (standard of error)



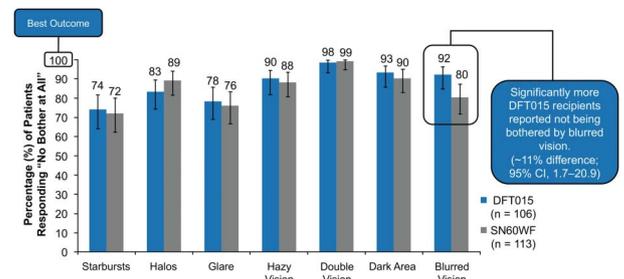
**Figure 2.** Mean binocular defocus curves at month 6 (all-implanted analysis set). Error bars represent 95% CIs.

**Visual Acuity by Pupil Size** Overall, visual acuity was consistent across all 3 categories of pupil size (small [ $<3$  mm], medium [3 to 4 mm], or large [ $>4$  mm]) and at all distances at month 6. For binocular CDVA, the mean logMAR ranged from  $-0.027$  to  $-0.028$  in patients implanted with DFT015 across all pupil sizes and from  $-0.027$  to  $-0.077$  with SN60WF. For binocular DCIVA, the mean logMAR ranged from 0.043 to 0.087 logMAR in patients implanted with DFT015 across all pupil sizes and from 0.178 to 0.213 logMAR with SN60WF. For binocular DCNVA, the mean logMAR ranged from 0.207 to 0.271 in patients implanted with DFT015 across all pupil sizes and from 0.340 to 0.404 with SN60WF.

**Spectacle Use** At month 6, spectacle use was shown to be reduced in the DFT015 implantation group compared with the SN60WF implantation group; 18.0% more patients implanted with DFT015 ( $n = 22$ , 21.6%) than with SN60WF ( $n = 4$ , 3.6%) “never” needed spectacles overall (95% CI, 9.65-27.37), with a high percentage of patients in the DFT015 group “never/rarely” needing spectacles for distance and intermediate tasks ( $n = 96$  [94.1%] and  $n = 89$  [87.2%], respectively). In addition, in both bright and dim light, at least 28.7% more patients implanted with DFT015 than with SN60WF reported “good” or “very good” vision without the use of spectacles at intermediate and near distances, whereas similar proportions of patients implanted with each IOL reported “good” or “very good” distance vision (Supplemental Table 1, <http://links.lww.com/JRS/A602>).

### Safety Outcomes

Overall, the rates of ocular AEs reported in both first and second eyes were low ( $<3\%$  for any individual AE) and similar between treatment groups.<sup>11</sup> The rates of cumulative serious AEs (SAEs), including secondary surgical interventions, for first and second eyes with DFT015 were also similar to those for SN60WF, with no cumulative SAEs exceeding the established rates according to the ISO 11979-7:2014 safety thresholds (Supplemental Table 2, <http://links.lww.com/JRS/A602>).



**Figure 3.** Proportion of patients reporting “not bothered at all” from visual disturbances at month 6. Error bars represent 95% CIs.

links.lww.com/JRS/A602). There were no persistent ocular SAEs in either treatment group. In total, ocular SAEs were reported in 5 eyes (2.3%) implanted with DFT015 and 5 eyes (2.2%) implanted with SN60WF (Supplemental Table 2, <http://links.lww.com/JRS/A602>).

No SAEs relating to the design features of the IOL were reported with DFT015, unlike SN60WF, which reported 1 device-related SAE (negative dysphotopsia resulting in explant). However, a nonserious device-related AE of photophobia was reported for 2 eyes (0.9%; both in the same patient) implanted with DFT015.

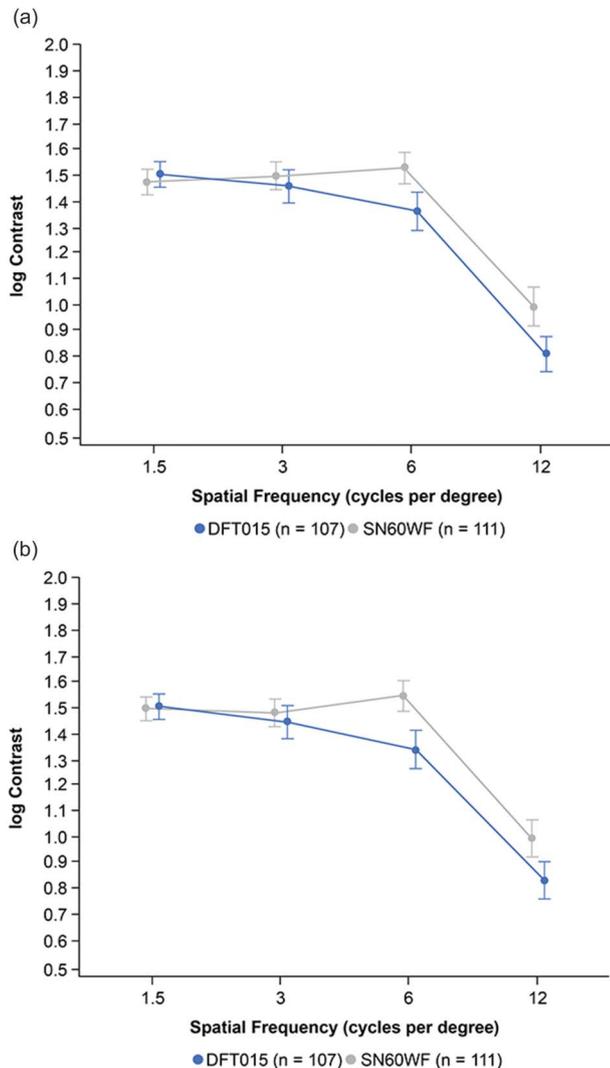
The rates of individual severe and most bothersome visual disturbances reported with DFT015 implantation were low for both IOLs at month 6 (DFT015, severe:  $\leq 3.8\%$ ; most bothersome:  $\leq 1.9\%$ ; SN60WF, severe:  $\leq 2.7\%$ ; most bothersome:  $\leq 1.8\%$ ) and at month 1 (DFT015, severe:  $\leq 4.8\%$ ; most bothersome:  $\leq 1.9\%$ ; SN60WF, severe:  $\leq 1.8\%$ ; most bothersome:  $\leq 0.9\%$ ).

The proportion of patients who reported “not bothered at all” by individual visual disturbances was also similar for both DFT015 and SN60WF, although significantly more patients implanted with DFT015 reported “not bothered at all” with blurred vision compared with SN60WF (11.3% difference; 95% CI, 1.7-20.9) (Figure 3).

Per ISO 11979-7:2014, losses of 0.3 log units that occur at 2 or more spatial frequencies are considered to be clinically significant. At month 6, DFT015 was associated with a slight reduction in monocular mesopic contrast sensitivity, with and without glare, compared with SN60WF (Figure 4, a and b), as evidenced by a reduction in the mean log contrast sensitivity with the higher spatial frequency test conditions. However, differences in mean monocular mesopic contrast sensitivity, with and without glare, between DFT015 and SN60WF (first eyes) were  $\leq 0.21$  log units at each of the spatial frequencies tested.

### DISCUSSION

The results of this prospective, multicenter, randomized controlled clinical study showed that the DFT015 EDOF IOL with a new nondiffractive design exceeded ANSI EDOF criteria (ANSI Z80.35-2018) by improving the range of vision from distance to near compared with the control SN60WF aspheric monofocal IOL, while maintaining a similarly low visual disturbance profile.<sup>6</sup> Specifically, DFT015 was shown to be effective in providing a



**Figure 4.** Mean monocular mesopic contrast sensitivity (a) with glare and (b) without glare at month 6, first eye (safety analysis set). Error bars represent 95% CIs.

continuous range of vision with superior intermediate (66 cm) and near (40 cm) vision and noninferior at distance vision compared with SN60WF, resulting in reduced spectacle use with DFT015 compared with SN60WF. A slight reduction in monocular mesopic contrast sensitivity with and without glare was observed with DFT015 compared with SN60WF at the highest spatial frequency tested. However, patient-reported quality of vision with DFT015 at distance in dim light was at least as good as SN60WF, and there were no differences in how bothersome patients found hazy vision to be between groups, as assessed by the QUID, whereas more patients with DFT015 were “not bothered at all” by blurry vision.

Overall, these findings are supported by those of another prospective, multicenter, randomized controlled clinical study (N = 282; NCT03010254) conducted across 19 investigational sites in 4 countries (Australia, Canada, Spain, and the United Kingdom).<sup>12</sup> This study also investigated the use of DFT015 compared with SN60WF in patients scheduled for bilateral

cataract surgery, with efficacy and safety outcomes assessed up to month 6 postoperatively.<sup>12</sup> Data at month 6 showed that DFT015 exceeds ANSI EDOF criteria by not only providing patients with superior DCIVA compared with SN60WF ( $-0.139$  logMAR difference;  $P < .001$ ), noninferior CDVA, a greater monocular DoF (0.52 D at 0.2 logMAR in favor of DFT015), decreased spectacle use, and a higher proportion of patients achieving a monocular DCIVA of 0.2 logMAR or better but also providing superior DCNVA (40 cm) compared with SN60WF ( $-0.098$  logMAR difference;  $P < .001$ ) while maintaining a monofocal-like visual disturbance profile.<sup>12</sup>

The mean monocular and binocular defocus curves for DFT015 in the U.S.-based study presented here showed a clear broadening of the plateau at distance, indicating that there is some tolerance for refractive error. It is worth noting that the SN60WF monofocal IOL achieved a relatively high monocular DoF. The 0.2 logMAR visual acuity provided by the SN60WF IOL at 66 cm is due to the  $-0.2$   $\mu\text{m}$  aspheric surface. This surface only partly corrects the natural corneal spherical aberration, thereby retaining some natural DoF. Monocular DoF values within this range have been previously reported for SN60WF in other multicenter clinical trials.<sup>16</sup> TECNIS Eyhance (Johnson & Johnson Surgical Vision, Inc.) is another monofocal IOL, referred to as an “enhanced monofocal,” that extends DoF to some degree using a refractive optical design with a higher-order aspheric anterior surface that creates a continuous power progression.<sup>17</sup>

The results of our study also clearly show that the nondiffractive design of DFT015 results in a visual disturbance profile similar to that of an aspheric monofocal IOL, with low rates of severe and bothersome visual disturbances ( $\leq 3.8\%$  and  $\leq 1.9\%$ , respectively, at 6 months). This is in contrast to diffractive technologies that extend DoF such as the ZXR00 IOL (TECNIS Symphony), for which the reported rates of severe visual disturbances can be as high as 36%.<sup>18,19</sup> As with the effectiveness outcomes, the safety findings of this study are supported by the results of the study by Bala et al. evaluating DFT015 compared with SN60WF, with the proportion of patients who reported “not bothered at all” by individual visual disturbances at month 6 (DFT015: 72.6%, 75.5%, and 73.6% for starbursts, halos, and glare, respectively; SN60WF: 63.8%, 77.5%, and 57.5%, respectively; all assessed using the Quality of Vision questionnaire) broadly consistent with the QUID results reported here.<sup>12</sup>

Cross-study comparisons of nondiffractive EDOF IOLs are challenging because of (1) the lack of consensus regarding the EDOF nomenclature and what constitutes true theoretical or functional EDOF IOLs and (2) the variations in methodology, reported outcome measures, and end points across studies.<sup>20,21</sup> The clinical relevance of this topic has prompted considerable efforts to provide a comprehensive overview of evidence on different EDOF IOLs’ performance and a framework to evaluate patient-reported outcome measure results from different methods, which have culminated in the recent publication of a review by Kohnen and Suryakumar.<sup>21</sup> The authors underline how the

degree of visual disturbance associated with a particular IOL depends on a range of factors, including IOL optics, material, and mechanics. Although many studies evaluating EDOF IOLs include subjective assessments of visual symptoms, the types of patient-reported outcome measures used to capture these results are inconsistent across studies, complicating data contextualization.<sup>21</sup> In general, nondiffractive approaches to EDOF IOLs, such as the DFT015, IC-8, and Mini WELL Ready IOLs, are likely to result in a lower degree of visual disturbances than diffractive approaches; however, as described, studies cannot be directly compared, and randomized controlled trials are needed to corroborate findings.<sup>21,22</sup>

Furthermore, DFT015 was designed for ease of use and ease of insertion, with a single-piece IOL that can be folded and implanted into the capsular bag through an incision smaller than the optic diameter of the lens, and nondiffractive technology meaning that less screening for tolerance (eg, for a multifocal IOL) is required.<sup>11</sup> The ease of use and generally broad applicability of DFT015 may help expand the population that can benefit from EDOF IOL implantation. However, further research is required to understand the expanded patient populations that could benefit from this IOL. Moreover, the DFT015 toric models are built on the stable SN6AT3-T6 (AcrySof IQ Toric) platform, which can be used to correct corneal astigmatism that often coexists in patients undergoing cataract surgery. A benefit from the current study was the biometry and refraction data that were collected and ultimately used to clinically optimize the SRK/T formula for DFT015 at a suggested starting point of 119.2.

One strength of this study was the use of the validated patient-reported outcome measures to assess visual disturbances, spectacle use, and patient satisfaction (QUVID and IOLSAT questionnaires). Many available tools are not fully validated and can produce variable results. To address this, FDA guidance on patient-reported outcome instrument development was followed to validate these questionnaires over several years, involving qualitative evaluation and assessment of reliability, construct validity, and the ability to detect changes. The end results were fit for purpose questionnaires recognized by the FDA as validated assessment tools.

In conclusion, the results of this clinical study demonstrate that DFT015 is safe and effective for the visual correction of aphakia. Overall, the DFT015 IOL improved distance-corrected intermediate and near vision, increased the DoF, and decreased spectacle wear compared with the SN60WF aspheric monofocal control IOL, with similarly low rates of visual disturbances and AEs. As such, DFT015 may broaden the patient population that may benefit from IOL implantation.

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### WHAT WAS KNOWN

- Multifocal IOLs use diffractive or refractive technology to provide continuous vision across focal lengths. However, multifocal IOLs are associated with increased visual disturbances and reduced contrast sensitivity.
- DFT015, a new, nondiffractive, EDOF IOL, was designed to provide continuous extended range of vision while minimizing issues with visual quality.

### WHAT THIS PAPER ADDS

- DFT015 provided superior intermediate and near vision and comparable distance vision and a visual disturbance profile similar to the aspheric monofocal IOL, SN60WF.

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