# Visual acuity and contrast sensitivity: AcrySof ReSTOR apodized diffractive versus AcrySof SA60AT monofocal intraocular lenses

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**PURPOSE:** To compare the visual acuity and contrast sensitivity in eyes with the AcrySof ReSTOR multifocal intraocular lens (IOL) (Alcon) and eyes with the monofocal AcrySof SA60AT IOL.

**SETTING:** Policlinico Umberto I, Department of Ophthalmology, Rome, and private clinical practice, Rome, Italy.

**METHODS:** One hundred eyes had phacoemulsification cataract extraction and implantation of a ReSTOR multifocal IOL in the capsular bag. Inclusion criteria were corneal astigmatism less than 1.5 diopters (D), myopia less than 4.0 D, and no associated ocular disease. A complete ophthalmic examination, including uncorrected visual acuity, best spectacle-corrected visual acuity, and contrast sensitivity, was performed 6 months postoperatively. Results were compared with those in 40 eyes with the AcrySof monofocal IOL single-piece IOL.

**RESULTS:** In the multifocal group, 90 eyes (90%) had an uncorrected distance visual acuity of 20/25 or better (logMAR <0.10) and an uncorrected near visual acuity at 35 cm of J3 or better (logMAR 0.14). The multifocal group and monofocal group had similar distance uncorrected and best corrected visual acuities; however, the multifocal group had significantly better near uncorrected acuity. The mean contrast sensitivity values were 18.28 dB (static program) and 17.95 dB (dynamic program) in the multifocal group and 19.18 dB (static program) and 21.2 dB (dynamic program) in the monofocal group.

**CONCLUSIONS:** The ReSTOR multifocal IOL provided a satisfactory full range of vision; 92% of the patients achieved total spectacle independence. Contrast sensitivity was lower than with the SA60AT monofocal IOL.

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The treatment of presbyopia is a challenge for ophthalmic surgeons. The choices include implantation of multifocal intraocular lenses (IOLs). According to the current literature, these IOLs improve near vision without a major adverse effect on distance vision.[1–3] In addition, the functional status and quality of life of patients with multifocal IOLs have been reported to be better than in patients with monofocal IOLs.[4] However, significant shortcomings, such as halos, glare, and loss of contrast sensitivity, especially in dim light, have been reported with multifocal IOLs.[5]

The AcrySof ReSTOR apodized diffractive IOL (Alcon) has a single-piece biconvex optic. The optic is of a high-refractive-index (1.55) hydrophobic, flexible, acrylic material with ultraviolet wavelength–absorbing properties (AcrySof ReSTOR, Physician Labeling. Rev. I. Fort Worth, TX, Alcon Laboratories, 2004). The anterior surface has apodized diffractive concentric rings in the central 3.6 mm area, distributing light for a full range of vision. Step heights decrease smoothly from 1.3 mm in the central zone to 0.2 mm at the diffractive periphery. The IOL incorporates a +4.0 diopter (D) addition (add) lens plane equal to

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a +3.2 D at the spectacle plane. This allows optimum near vision approximately 31 cm from the eye. The 2 technologies in the ReSTOR—apodization and the diffractive optic—reduce the light transmission loss that is common with other diffractive IOLs.[6]

We studied the postoperative visual acuity and contrast sensitivity in patients who had cataract extraction and AcrySof ReSTOR SA60D3 multifocal IOL implantation and compared the results with those in patients with AcrySof SA60AT monofocal IOLs to evaluate the difference in visual function in the 2 groups. The SA60AT IOL is monofocal, single piece, and anterior asymmetric biconvex and has a 6.0 mm acrylic optic. The single-piece design and acrylic material are the same as those of the ReSTOR multifocal IOL.

## PATIENTS AND METHODS

This retrospective comparative study comprised 70 patients with senile cataract who had phacoemulsification and posterior chamber IOL implantation from December 2005 to April 2006. The approval of the ethics committee was not required for the study because the IOLs used were available on the Italian IOL market and approved as a surgical device by the National Health Ministry of Italy.

Fifty patients (100 eyes) were allocated to receive the AcrySof ReSTOR IOL (multifocal group) and 20 patients (40 eyes), the AcrySof SA60AT (monofocal group). Inclusion criteria in both groups were age 50 to 80 years, cataract in both eyes classified by the Lens Opacities Classification System III, corneal astigmatism less than 1.5 D, potential acuity meter reading better than 0.2 logMAR units, and axial length between 23.0 mm and 24.0 mm. Exclusion criteria were anterior segment pathology such as chronic uveitis, zonular dialysis, pseudoexfoliation syndrome, and glaucoma; posterior pathology such as diabetic retinopathy; and macular pathology. Patients with previous anterior and posterior segment surgery and intraoperative or postoperative complications were also excluded.

Patients were scheduled for clinical evaluation preoperatively and 1 day, 1 week, and 1, 3, and 6 months postoperatively. Patients with at least 6 months of follow-up were included in the study. A standard comprehensive ophthalmic examination, including manifest refraction, biomicroscopy, intraocular pressure measurement, and funduscopy, was performed at all visits. Photopic measurements were performed at 180 candelas/$m^2$ with use of the Early Treatment Diabetic Retinopathy Study (ETDRS) chart luminance. Keratometry was performed manually. Immersion ultrasound biometry was performed in all patients using the OcuScan RxP Ophthalmic Ultrasound System (Alcon Laboratories).

The IOL power was targeted for emmetropia using the Holladay 1 and SRK/T formulas according to the measured axial length.

Uncorrected and best corrected distance visual acuities were measured monocularly and binocularly in logMAR units and decimal units. Uncorrected, distance corrected, and best corrected near visual acuities were measured monocularly and binocularly in logMAR units and converted to Jaeger standard with an ETDRS near chart at 35 cm and with 100% contrast. The spherical add power was limited to 1.50 D (multifocal group) and 3.00 D (monofocal group) to ensure the best corrected near visual acuity.

Cataract surgery was performed by 2 experienced surgeons (???, ???). The standard technique in all patients consisted of sutureless phacoemulsification using the Legacy 2000 series unit (Alcon Laboratories), a clear corneal incision up to 3.0 mm, and a 5.0 to 5.5 mm capsulorhexis. The IOLs were implanted using the Monarch II injector (Alcon Laboratories). The surgery in the fellow eye was performed within 30 days in all patients.

Contrast sensitivity was measured monocularly with best distance correction with the Vision Monitor MonCRS WIN8000D (Metrovision) 6 months postoperatively. The test was performed with both static and dynamic photopic programs.

## RESULTS

The mean age of the patients was 64.8 years (range 50 to 80 years) in the multifocal group and 67.8 years (range 52 to 76 years) in the monofocal group. The ratio of men to women was the same in the 2 groups. The mean preoperative best corrected distance and near visual acuities were 0.45 (0.35 logMAR units) and 0.09 logMAR, respectively, in the multifocal group and 0.54 (0.27 logMAR units) and 0.08 logMAR, respectively, in the monofocal group.

In the multifocal group, the mean pupil diameter under scotopic conditions (luminance 0.0001 cd/$m^2$) was 4.89 mm and under photopic condition (luminance 200 cd/$m^2$), 2.84 mm. In the monofocal group the means were 4.78 mm and 2.81 mm, respectively.

No surgical complications were encountered in the series.

Tables 1A and 1B show the visual acuity results 6 months after surgery in the multifocal group. Six months after surgery, the mean monocular uncorrected distance visual acuity in the multifocal group was 0.91 (0.06 logMAR), with 90% of the patients achieving an uncorrected distance visual acuity of 0.8 (logMAR $<0.10$) or better. The mean uncorrected distance visual acuity in the monofocal group was 0.86 (0.7 logMAR). Best corrected distance visual acuity was 0.9 or better in 94% of patients in the multifocal group and 96% in the monofocal group.

The mean uncorrected monocular near acuity was $0.10 \pm 0.032$ logMAR at 35 cm in the multifocal group.

**Table 1A.** Distance visual acuity results 6 months after surgery in the multifocal IOL group (N = 100).

| | | Number (%) | |
|---|---|---|---|
| Distance Acuity | Mean LogMAR (Snellen) | 20/40 or Better | 20/25 or Better |
| Uncorrected | 0.06 (20/23) | 98 (98) | 90 (90) |
| Best corrected | 0.05 (>20/23) | 100 (100) | 98 (98) |

**Table 1B.** Near visual acuity results 6 months after surgery in the multifocal IOL group (N = 100).

| | | Number (%) | |
|---|---|---|---|
| Near Acuity | Mean LogMAR (Jaeger) | J2 or Better | J1 |
| Uncorrected at standard distance | 0.10 (J2 or better) | 96 (96) | 86 (86) |
| Distance corrected at standard distance | 0.07 (J1) | 97 (97) | 92 (92) |
| Best corrected at standard distance | 0.04 (J1) | 100 (100) | 98 (98) |

In the monofocal group, the mean best corrected (add +3.0 D) near acuity was 0.07 ± 0.024 logMAR. In the multifocal group, the mean best corrected near acuity (maximum add +1.5 D) was 0.04 logMAR at 35 cm (J1) in all eyes.

The monocular static photopic contrast sensitivity measurement was not statistically significantly different in the 2 groups at spatial frequencies of 0.5, 1, 1.5, 2, 6, and 13 cpd (Figure 1) ($P < .05$). It was statistically significantly lower in the dynamic photopic program in the multifocal group ($P < .05$) (Figure 2).

Twenty-two percent of patients in the multifocal group and 15% in the monocular group reported nighttime halos. Five patients in the multifocal group reported visual disturbances. Approximately 28% of the patients in the multifocal group and monofocal group reported mild to moderate glare. Despite the nighttime halos, 90% of patients in the multifocal group stated they had good quality near vision and 94% said they had good quality distance vision. Ninety-two percent in the multifocal group and 12% in the monofocal group achieved total spectacle independence after bilateral IOL implantation.

## DISCUSSION

In our study, the ReSTOR SA60D3 multifocal IOL group had 6-month postoperative efficacy, stability, and safety results comparable to those in previous reports[7–9] (T. Kohnen, MD, "Near and Distant VA with the AcrySof ReSTOR IOL," presented at the ASCRS Symposium on Cataract, IOL and Refractive Surgery, San Francisco, California, USA, April 2003). There seemed to be fewer complaints of photic phenomena and visual symptoms in our group. In our study, 92% of patients in the multifocal group reported total independence from spectacles, a percentage slightly higher than reported in the literature (80% to 86%).

The incidence of halo and glare in the multifocal group was 22% and 28%, respectively. The posterior capsule opacification (PCO) and neodymium:YAG (Nd:YAG) capsulotomy rates were 32% and 23%, respectively. In the monofocal group, the incidence of halo was 15% and night glare was 12%; the PCO rate was 18%, and 16% of the eyes required an Nd:YAG capsulotomy.

These results confirm that multifocal IOLs are associated with a higher incidence of visual disturbance. Although we used IOLs of the same hydrophobic acrylic material, the PCO frequency was higher in the multifocal group.

The IOLs were centered in all the eyes 6 months after surgery. No patient requested IOL explantation because of visual disturbances.

Our results were achieved by strict patient selection, an important factor in good patient satisfaction. Patients must be counseled about the possibility of undesirable visual symptoms, in particular halos and glare.

All eyes had less than 1.5 D of corneal astigmatism preoperatively. During surgery, we used the Monarch II IOL injector so we could use a small (3.0 mm) incision. Corneal access was temporal or superotemporal in all cases, and hydrosuture was performed to obtain the least postoperative corneal astigmatism. To avoid

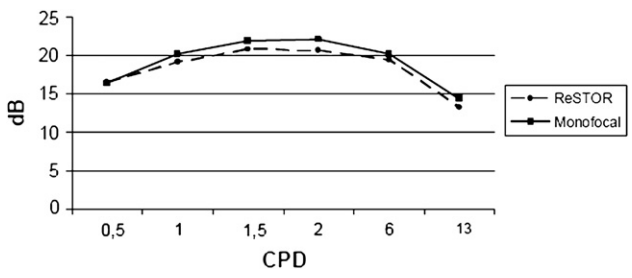


**Figure 1.** Contrast sensitivity with the static photopic program.

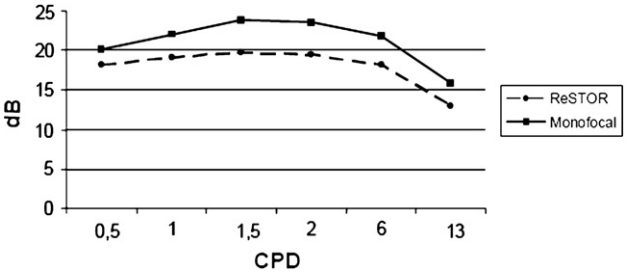


**Figure 2.** Contrast sensitivity with the dynamic photopic program.

halo and glare, pupil size and activity were studied by pupillometry in the multifocal group to exclude patients with reduced pupil size and poor activity.

Before we selected patients for multifocal IOL implantation, we asked about their routine activities and whether they were interested in spectacle independence. This was done to exclude patients who use computer monitors for long periods of time because the satisfaction level for intermediate vision is lower than for near and far distance. Patients who had to drive at night were also excluded as night glare would be a limitation.

Our contrast sensitivity measurements are comparable to those in the current literature[10] and confirm that apodized diffractive ReSTOR technology reduces light transmission loss compared with other diffractive multifocal IOLs and that the difference with monofocal IOLs is lower than other multifocal IOLs.[11]

In conclusion, we achieved excellent far and near distance visual acuity results with the apodized diffractive multifocal ReSTOR IOL; intermediate distance vision was not tested. Most patients achieved a visual acuity of 20/40 or better without major intraoperative or postoperative complications. The AcrySof ReSTOR multifocal IOL provided a satisfactory full range of vision and achieved a high percentage of spectacle independence compared with the SA60AT monofocal IOL; however, contrast sensitivity was lower in the multifocal group. Patient satisfaction after bilateral implantation of the AcrySof ReSTOR multifocal IOL was good.

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