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Complementary IOLs: A New Approach for a Continuous Range of Vision

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The art and science of presbyopia correction are rapidly evolving to meet patient expectations. Complete restoration of the accommodative function (ie, the ability to focus at any distance) is currently not possible; however, recently developed approaches to the correction of presbyopia have been able to alleviate the symptoms to the point where patients can resume their daily activities with no impediment related to their vision. The ideal outcome for a presbyopic patient would be the complete restoration, to prepresbyopic levels, of the dioptric interval within which the patient can smoothly and rapidly achieve sharp vision.[1]

NO PERFECT OPTION

Bifocal, trifocal, and EDOF IOLs are well-known options to partially restore the ability to focus at several distances. The first trifocal IOLs were developed 10 years ago to overcome the need for acceptable intermediate vision, which could not be provided by bifocal IOLs.

One main limitation of multifocal IOLs on the market today is the discontinuity of their depth of focus (DOF). A noncontinuous DOF requires patients to go through a learning curve for their new way of seeing, in which only objects at certain distances (the far and near foci on bifocals, with the addition of an intermediate focus on trifocals) are seen distinctly.

In between these sharp vision foci, blur can be bothersome and incapacitating. EDOF lenses have overcome this limitation to a degree, providing an extended and continuous range of vision from far to intermediate distances, but they are unable to restore vision at near. Patients and surgeons must make a choice between a continuous DOF or near vision.

One approach to overcoming this limitation is the implantation of different addition powers or different IOL designs in a patient's two eyes (ie, mix-and-match and modified monovision). These strategies rely on the binocular summation of images and the selection of the best image by the neural part of the visual system.

Depending on the approach used, bifocal IOLs of different addition powers (mix-and-match) have resulted in better distance corrected near visual acuity and better patient satisfaction than bilateral implantation of the same bifocal add power, without compromising contrast sensitivity, stereopsis, or visual acuity at other distances.[2] Further, bilateral implantation of

the same model trifocal IOL produced better intermediate and near visual acuity and contrast sensitivity than mixing and matching bifocal IOLs with different addition powers.[3,4]

Agreement on this approach is far from unanimous, especially because the mix does not always match the multifocal IOLs' disparity. And discontinuity in visual acuity between far and near distances still exists throughout all these strategies.

A NEW APPROACH

An international multicenter study, with participating ophthalmologists including Tanneguy Raffray, MD, in France; Oliver Findl, MD, MBA, in Austria; and our group in Spain, is investigating an approach based on the binocular summation of images with a new set of complementary IOLs. The Artis Symbiose Mid and Plus IOLs (Cristalens Industrie) are two IOLs designed to be implanted binocularly. These preloaded one-piece diffractive IOLs employ a four-closed-loop haptic configuration and are made of a clear hydrophobic material (Figure 4).

Figure 4. The Artis Symbiose Mid (right) and Plus (left) set of IOLs.

Courtesy of Cristalens Industries

The diffractive technology used in the lens optics, based on the innovative concept of continuous phase, achieves multifocality and avoids low-contrast image gaps between the intermediate and near foci without compromising far vision. The add power continuously covers from 1.50 to 3.75 D at the IOL plane.

The Artis Symbiose Mid IOL is superior for intermediate distances, and the Artis Symbiose Plus is superior for near distances. Figure 5 shows the through-focus modulation transfer function (TFMTF) of both lenses superimposed to illustrate their complementarity.[5] Note that there is a point around -2.75 D of defocus (at the IOL plane) where both TFMTF curves meet, with an MTF value of 0.15. Therefore, when the two lenses are implanted bilaterally, one of the two eyes will always have an MTF value above 0.15 that occurs between 1.50 and 3.75 D of defocus. Thus, the binocular combination of the two IOLs will provide a continuous DOF to patients from 90 to 40 cm, as used in most of the intermediate and near distance tasks of daily living, if tolerated by neural adaptation.

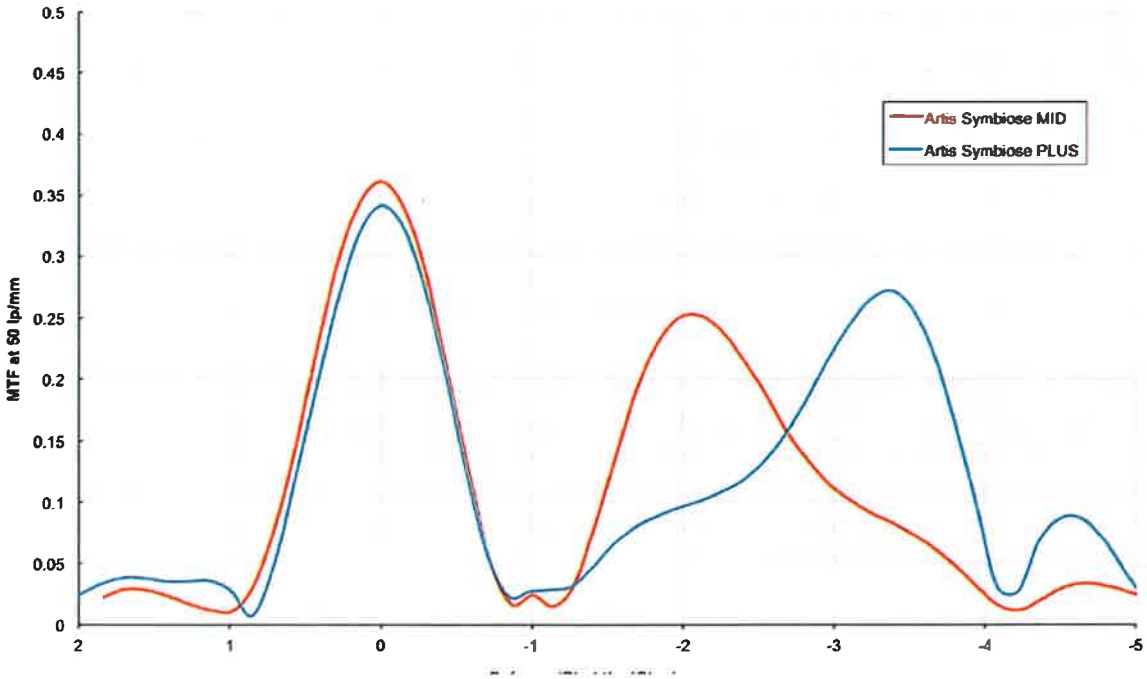

Figure 5. Through-focus modulation transfer function at 50 lp/mm for the Artis Symbiose Mid (red line) and Plus (blue line) lenses. Measurements were taken in vitro using an optical bench (PMTF, Lambda-X) and an eye model with spherical aberration to simulate that of the cornea.[5]

STUDY EXPERIENCE

At the beginning of 2019, the Vista Ircovisión clinics started participation in the aforementioned study to document clinical outcomes in patients implanted with the Artis Symbiose lenses. Our main purpose was to investigate the ability of this set of IOLs to provide a continuous binocular DOF from intermediate to near distances. The monocular and binocular defocus curves and contrast sensitivity measurements for the first 10 patients to reach the 1- to 2-month follow-up visit were presented at the 2019 ESCRS Annual Meeting.[6]

Figure 6 shows the monocular and binocular distance-corrected defocus curves for these patients under photopic conditions (~500 lux). Note that the monocular defocus curves produce a meeting point at -2.00 D of defocus at the corneal plane, similar to that of the TFMTF curves shown in Figure 5 at -2.75 D of defocus at the IOL plane.

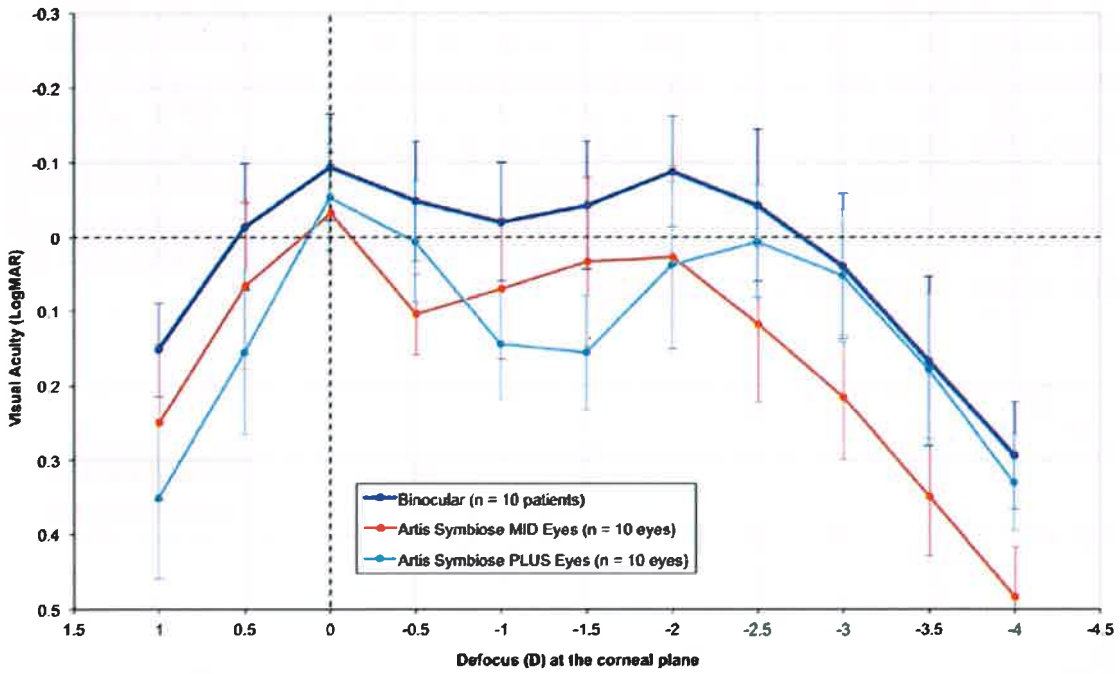

Figure 6. Distance-corrected mean monocular and binocular (dark blue line) defocus curves for the first 10 patients at 1- to 2-month follow-up. The light blue line represents the monocular defocus curve of the eyes implanted with the Artis Symbiose Plus IOL, and the red line represents that of the eyes implanted with the Artis Symbiose Mid IOL. Error bars represent ± standard deviation. Measurements were taken with an ETDRS optotype at 4 m in photopic conditions (~500 lux).[6]

Figures 5 and 6 courtesy of Juan F. Zapata-Díaz, DOO, MSC, PhD

The most notable observation is the binocular continuous DOF, with visual acuity better than 0.05 logMAR from 0.00 to -3.00 D of defocus at the corneal plane. There are none of the visual gaps previously observed with other lens combinations, confirming these patients' neural adaptation to the binocular combination of the Artis Symbiose IOLs in photopic conditions.

Patient satisfaction was very high (mean score, 88.19 of 100 with the VF-14 questionnaire), and, so far, all patients are spectacle independent. Mean contrast sensitivity was inside the normal values for ages 50 to 75 years in photopic conditions.

We do not usually expect patients implanted with multifocal IOLs to be able to read immediately or soon after surgery. We were surprised to see how many patients were able to read just outside the OR after surgery. In no case did we observe a near vision learning curve. All patients could resume their daily activities immediately.

Longer-term outcomes will tell us more about the typical side effects of diffractive systems, such as dysphotopsias. Some of the patients (5 of 10) reported tolerable halos in the postoperative period. The functional burden should disappear with time, as it does for many patients with the typical diffractive trifocal and EDOF IOLs. Our ongoing study and a longer follow-up of the multicenter study will determine the answers to these questions.

CONCLUSION

We have found that the combination of the Artis Symbiose Mid and Plus IOLs can provide a continuous binocular depth of field from infinity to 33 cm in photopic conditions with no need of an adaptation period and with normal contrast sensitivity. Patient satisfaction has been high, and, so far, none of the study participants implanted with this lens combination are using spectacles.

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