

## Testing and reporting contrast sensitivity

In their recent article about the Tecnis intraocular lens (IOL), Muñoz et al.<sup>1</sup> report elimination of the spherical aberration ( $-0.0321 \pm 0.2856 \mu\text{m}$  for the Tecnis IOL versus  $0.1511 \pm 0.1709 \mu\text{m}$  for the AR40e IOL and  $0.2115 \pm 0.2131 \mu\text{m}$  for the Stabibag IOL) that is consistent with results in previous publications,<sup>2-6</sup> which have shown that implantation of a modified prolate IOL with  $-0.27 \mu\text{m}$  of spherical aberration produces a mean total ocular spherical aberration equivalent to zero. The authors also found that eyes with the Tecnis Z9000 had a greater Strehl ratio after surgery. However, they did not find a significant difference in contrast sensitivity between eyes implanted with the Tecnis Z9000 and fellow eyes implanted with either control IOL. The absence of a significant difference in contrast sensitivity at any spatial frequency runs counter to previous reports comparing the Tecnis Z9000 IOL and the AR40e,<sup>7-9</sup> as well as reports comparing the Tecnis with a variety of other spherical IOLs.<sup>10-12</sup> The findings also directly contradict one publication that demonstrates significantly better visual acuity and better (although not statistically significantly better) contrast sensitivity<sup>13</sup> and indirectly contradicts the findings of another report that shows significantly better contrast acuity following mydriasis.<sup>14</sup>

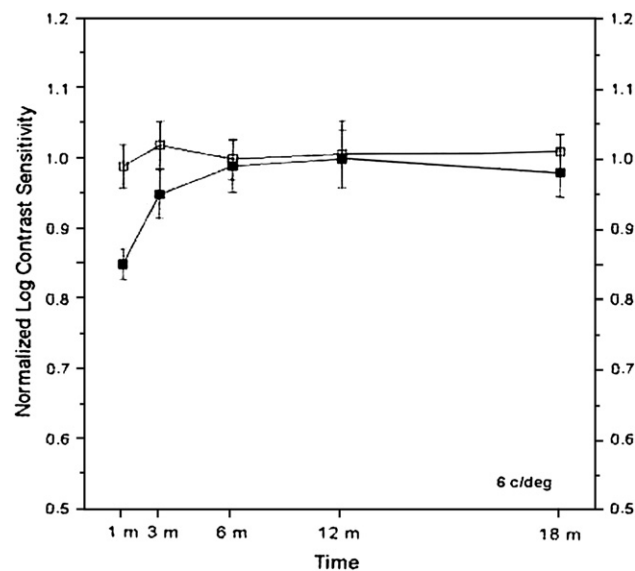
Muñoz et al.<sup>1</sup> suggest several possible explanations for their findings, including IOL material, chromatic aberration, and IOL decentration (although they admit that their finding of reduced coma in the eyes implanted with the Tecnis IOL provides evidence against decentration). However, we were surprised they did not mention that the values they show for normalized contrast sensitivity in all eyes are abnormally low under both photopic and mesopic conditions.

We are concerned that the normalized contrast sensitivity values reported in this article are lower than expected for all tests, including the Z9000, AR40e, and Stabibag IOL eyes. In a previous publication by some of the same authors,<sup>15</sup> normalized contrast sensitivity values in pseudophakic patients with spherical monofocal and multifocal IOLs were close to 1.0 at all spatial frequencies by 3 months postoperatively (Figure 1). It has also been demonstrated that the contrast sensitivity in pseudophakic patients implanted with spherical IOLs is the same as that in age-matched controls without cataract, and thus the pseudophakes would be expected to have normalized contrast sensitivity approximating 1.0.<sup>16</sup> The significantly lower values for contrast sensitivity reported in this paper suggest the possibility of an error in testing conditions, protocol, data management, or analysis.

One test condition that could create lower contrast sensitivity in the current study compared with that

in the previous publication<sup>15</sup> is the different contrast sensitivity testing systems used. The earlier publication used the FACT (Functional Acuity Contrast Test, Vision Sciences Research Corp.) and the present study used the VectorVision test system. The VectorVision contrast sensitivity system is less sensitive than the FACT system.<sup>17</sup> Compared with the FACT grating system, the VectorVision gratings change contrast with changes in room illuminance; the white grating surround creates a glare source and the grating patches are considerably smaller than the FACT gratings. An in-house study of 20 normal subjects (mean age 37 years [range 26 to 51 years]) with a best corrected visual acuity of 20/20 compared the contrast sensitivity of FACT and VectorVision at 6 and 12 cycles per degree (cpd) under photopic test conditions (unpublished data). Under normal test conditions, the contrast sensitivity of FACT was slightly, but not significantly, higher. However, under glare (BAT on medium) and low contrast (homogeneous light scatter material), the FACT was twice as sensitive in measuring contrast loss as the VectorVision at 6 and 12 cpd. The relative insensitivity of the VectorVision test to loss of contrast sensitivity also means the VectorVision is a relatively insensitive measure of contrast gains such as those reported previously with the Tecnis IOL and the FACT system.<sup>6</sup>

The differences in sensitivity to contrast between contrast test systems also cautions interpretation of



**Figure 1.** The normalized contrast sensitivity reported in a previous publication<sup>15</sup> for a spherical monofocal IOL (open squares) and a multifocal IOL (solid squares) at 6 cpd. The values are close to 1.0 for the spherical monofocal at all time points, whereas the values in the current publication vary from 0.6 (mesopic) to 0.8 (photopic). Reprinted with permission from Elsevier.

normalized test results such as that given by Boxer-Wachler and Kruger.<sup>18</sup> Two quite different contrast sensitivity values can give similar normalized values, masking significant changes in contrast sensitivity. For example, one contrast sensitivity test system having a normalized value of 0.8 for contrast sensitivity values of 100 and 80 may find the 80 below the normal population curve. However, another contrast sensitivity test system having a normalized value of 0.8 for contrast sensitivity values of 150 and 120 may find the 120 value within the normal population curve. Normalization only works for similar contrast test systems.

Measuring and reporting contrast sensitivity remains unfamiliar territory for most cataract and refractive surgeons. Variations in results should be elucidated with reference to differences in testing systems, procedures, and data analysis.

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**REPLY:** We appreciate this interesting letter discussing our paper about contrast sensitivity after cataract surgery with the Tecnis intraocular lens (IOL). In our paper, we found a statistically significant reduction of spherical aberration in patients implanted with the Tecnis IOL that was not associated with an improvement in visual acuity or contrast sensitivity at photopic or mesopic illumination levels.

Previous studies have found a reduction in spherical aberration accompanied by an improvement in visual acuity and contrast sensitivity. However, it must be realized that a statistically insignificant difference<sup>1</sup> should not be considered an actual difference. Regarding testing under mydriasis,<sup>2</sup> no comparison can be made with our paper's results since we did not take contrast sensitivity measurements under this condition.

There are also reports of better contrast sensitivity at some spatial frequencies with the aspheric Tecnis IOL than with nonprolate IOLs.<sup>3–7</sup> In these studies, the FACT chart was used to measure contrast sensitivity. It seems to be superior to the CSV1000E for measuring contrast sensitivity. However, we used the CSV1000E chart since at the time of our study, it was the only test available to us. We now have doubts about the sensitivity of CSV1000E measurements at mesopic levels because the test itself is a source of illumination, making the actual retinal illumination level difficult to control, and the test itself can create an important glare source. For these reasons, we now prefer the FACT chart for contrast sensitivity measurements.

We also believe that one limitation of our study is the population size, as stated in the discussion of the paper. We measured contrast sensitivity in 30 eyes of