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1. Kohnen T, Terai E, Kasper T, et al. Correlation of infrared pupillometers and CCD-camera imaging from aberrometry and videokeratography for determining scotopic pupil size. J Cataract Refract Surg 2004; 30:2116–2123

Reply: We would like to thank Cheng et al. for their comments. The Zywave unit used by them (commercial software 5.09) is different from the one used in our study (software 4.45SP2). Using the pupillometry function, software 5.09 has no fixation target light and the infrared laser runs continuously at 2 μW of power during the measurement. Software 4.45SP2 has no fixation target light, and the infrared laser runs continuously at 2 μW and then at 35 μW for 100 ms during each measurement. In our study, the measurement was the diameter of 3 averaged wavefront readings. However, even in the continuously running setup of the commercial system, there is variation in pupil size due to hippus that is on the order of the changes in pupil size one sees between the 3 measurements. Variations from day to day may be larger than the differences Cheng et al. are questioning in our measurements. It might be correct to use the largest recorded pupil size rather than an average for a better representation of the scotopic pupil size, but in the study mentioned by Cheng et al., the averaged Zywave measurement is compared with the scotopic Procyon measurement, which in itself represents the mean and standard error of 10 images acquired in 2 seconds at an illuminance level of 0.07 lux.[1]—*Thomas Kohnen, MD, Evdoxia Terzi, MD, Thomas Kasper, MD, Eva-Maria Kohnen, MD, Jens Bühren, MD*

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Prognosis of pseudophakic retinal detachment

In their retrospective review of 400 patients, Christensen and Villumsen[1] conclude that the surgical outcomes of pseudophakic and phakic retinal detachments are comparable. This finding agrees with that in another retrospective review of 243 consecutive phakic and pseudophakic individuals with primary retinal detachment who had had surgical repairs.[2]

However, if we take a closer look at the data presented by Christensen and Villumsen, a major incongruity with the previous studies is encountered. As pointed out by Halberstadt et al.,[3] the size of the retinal detachment significantly influences the surgical outcome in pseudophakic and phakic eyes with retinal detachment. In retinal detachments of more than 3 quadrants, the detachment size substantially affects the postoperative results in pseudophakic eyes more than it does phakic eyes.[3] According to Table 3 in the article by Christensen and Villumsen, large detachment of 3 or more quadrants occurred in 69 (24.6%) phakic and 38 (31.7%) pseudophakic individuals. No significant difference in the overall extent of detachments between groups was reported. Therefore, it may be inferred that the pseudophakic group should have done worse in terms of surgical outcome under the influence of a similar proportion of large retinal detachment compared with the phakic group. Other unmentioned confounding factors may have been operating and offsetting the influence of the large detachment in pseudophakic patients.

The authors' further enlightenment of this issue would be much appreciated.

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3. Halberstadt M, Brandenburg L, Sans N, et al. Analysis of risk factors for the outcome of primary retinal reattachment surgery in phakic and pseudophakic eyes. Klin Monatsbl Augenheilkd 2003; 220:116–121

Reply: We presented a retrospective review of the prognosis after pseudophakic retinal detachment comparing the visual results of 280 phakic detachments and 120 pseudophakic detachments. The detachments were treated with an identical surgical approach using an external technique and using only vitrectomy if obvious signs of proliferative vitreoretinopathy were found. The main objective of the study was to study this approach. We found that the proportion of patients with 3 and 4 quadrants detached was higher in the pseudophakic group (32% compared with 25% in the phakic group). This difference, however, is not statistically significant. We found that the visual success in the 2 groups was identical: 60% of phakic and 59% of pseudophakic eyes achieved visual acuity of 0.4 or better.

Our data regarding this matter do not support the conclusion of Halberstadt et al.,[1] possibly due to the limitations of a retrospective review.—*Ulrik Christensen, MD, Jørgen Villumsen, MD, DMSc, Copenhagen, Denmark*

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Aberrations after intraocular lens implantation

We read with great interest the report by Pesudovs et al.[1] regarding optical aberrations and intraocular lens (IOL) implantation, particularly the authors' conclusion that "visual performance did not differ despite differences in wavefront aberration." The

authors state that they found no significant differences in logMAR visual acuity or sine wave contrast sensitivity despite a significant difference in spherical aberration (difference in C_{12} = 0.18 μm for a 6.0 mm pupil, "PMMA-scleral" versus "AcrySof-corneal" groups). The authors do note, however, that "recent reports suggest the visual impact of spherical aberration differences from IOLs can be detected by contrast sensitivity," and state that their "results contradict this." Pesudovs et al. specifically cite our work as contradictory to theirs.[2]

We would like to point out that our work represents only 1 example of a growing body of published evidence that demonstrates improved functional vision with elimination of spherical aberration by means of a modified prolate IOL designed to correct corneal spherical aberration.[3–9] One additional unpublished but significant demonstration of improved functional vision with elimination of spherical aberration is reflected in the U.S. Food and Drug Administration–approved labeling for the Tecnis modified prolate IOL (AMO, Inc.), which states that the "spherical aberration of eyes implanted with the Tecnis IOL is not significantly different from zero" and that "there is a meaningful safety benefit for elderly drivers and those with whom they share the road," as well as "potential improvement in safety under low visibility for other activities of living" http://www.fda.gov/cdrh/pma/pmamar04.html (see also, package insert, Foldable Ultraviolet Light-Absorbing Posterior Chamber IOL, Tecnis, with Z-sharp Optic Technology, model Z9000, AMO, Inc.)

It is possible that the apparent contradiction highlighted by Pesudovs et al. may be resolved by the fact that studies demonstrating a correlation between elimination of spherical aberration and improvement in functional vision compare a modified prolate IOL to a variety of spherical IOLs, whereas those studies finding no difference in functional vision compare only spherical IOLs.

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I. Howard Fine, MD
Richard S. Hoffman, MD
Patricia Piers, MSC

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Reply: We thank Packer et al. for their interest in our article and for the opportunity to comment further on their work on the Tecnis intraocular lens (IOL). Despite a number of reports on the topic, there is not yet convincing evidence that the Tecnis IOL delivers any benefit to real-world visual performance. The articles cited by Packer et al. use a surrogate measure of real-world visual performance in the form of contrast sensitivity (CS) or low contrast visual acuity (LCVA). These data are at least 1 degree of separation away from what happens in the real world. Connecting the 2 relies on the assumption that a contrast domain measure and real-world visual performance are highly correlated. However, evidence suggests that this is not the case.

A number of studies have looked at the relationships between visual performance on a range of clinical tests and compared this to self-reported function or practical tests of real-world performance. Contrast domain tests are usually correlated better with real-world performance than high contrast visual acuity tests (HCVA); however, even highly significant correlations do not explain a high proportion of the variance in real-world performance, and differences between tests are not great. For example, in a study comparing real-world performance on a series of tasks with various tests of visual performance, the proportion of variance in real-world performance explained by visual performance was 74% for near HCVA, 64% for edge CS, 61% for distance HCVA, and 48% for peak CS.[1] In probably the most comprehensive article on the topic, Rubin et al.[2] found self-reported function was more strongly predicted by HCVA (odds ratio 2.39) than by CS (odds ratio 1.85). So while we encourage the use of contrast domain testing and agree that when added to HCVA it gives a more comprehensive appreciation of real-world visual performance, on its own the incremental gain over HCVA is a lot less than is commonly suggested. This misapprehension probably arises from the clinical experience with symptomatic patients with good HCVA who can be shown to have reduced CS. However, routine testing of CS will show that symptomatic patients can have reduced HCVA and normal peak CS.

So what are we to make of research that shows that CS is affected by aberrations but that HCVA is not? This is indeed possible because the redundant information in a high-contrast target makes it less sensitive to image degradation by aberrations, so LCVA is certainly a more sensitive clinical test than HCVA.[3] However, visual acuity testing is a more precise test than sinusoidal CS patch charts.[4] Indeed, a CS patch test like the Vistech and FACT charts contain serious design flaws that make their use in cataract or refractive surgery outcomes research inappropriate.[4,5] Specifically, the FACT chart has a truncated range of measurement so that people with normal vision can see the lowest contrast patch, producing a ceiling effect. Pseudophakes, especially those with low levels of spherical aberration, should have normal vision so many would see the lowest contrast patch. A study using this chart would be less likely to measure a difference between 2 types of IOLs in the presence of a real difference in visual

performance. Unfortunately, all studies comparing the Tecnis IOL with another IOL use the FACT chart and therefore suffer from these measurement flaws. Even if these flaws did not lead to invalid measurement, there is no direct evidence that the levels of CS gain reported translate into any real-world functional benefit, such as in a highly complex task like vehicle operation.

The findings of our report comparing spherical IOLs are important to the field of IOL research and fail to support work such as that produced on the Tecnis IOL.[6] We would like to stress that our research did not address the Tecnis IOL directly, just that our findings were worthy of comparison in the discussion. Although most studies looking at the Tecnis IOL do not report wavefront aberrations,[7,8] one study that did find visual performance differences (albeit with the FACT chart, at 2.2 to 3.2 mm pupils) attributed them to aberration differences of only 0.07 μm spherical aberration (4.0 mm pupil).[9] In contrast, we found much larger wavefront aberration differences between IOLs (0.24 μm total RMS, 0.18 μm spherical aberration for a 6.0 mm pupil), but these were not manifest as visual performance differences (also measured at a 6.0 mm pupil diameter, when the effects of any differences should be larger). This is important because it shows that we should not expect much visual performance difference for these relative levels of aberration, even under dilated pupil conditions, and that any effects are easily overpowered by other factors. Although we screened rigorously for age-related macular degeneration, capsular thickening, and all other pathology, subclinical changes at the macular and the posterior capsule are common and have much greater impact on contrast sensitivity than these levels of wavefront aberration differences. These findings give an important perspective to the benefit of controlling IOL aberrations. Critically, our research was conducted under the most controlled laboratory conditions for vision assessment and completely independently funded.

Although the theoretical benefits of an IOL with negative spherical aberration seems attractive, there are sound theoretical reasons against such a lens being of practical benefit: IOL decentration and tilt,[10,11] the large variance of corneal spherical aberration in the population,[12] postoperative uncorrected refractive error, capsular thickening, ARMD or other pathology, and pupil size. It is highly likely that such IOLs will only be beneficial in eyes with large pupils, average corneal spherical aberration, and small amounts of asymmetrical postsurgical aberration and then only if IOL placement is perfect, there is no residual refractive error, and no significant capsular thickening develops.

Improvements in IOL technology are an exciting area of research, and we encourage others to conduct high-quality outcomes research using appropriate outcome measures. Only through this approach can the cataract and refractive surgery community determine the difference between theoretical benefits and proven benefits.—*Konrad Pesudovs, PhD, Holger Dietze, MSc, Owen G. Stewart, FRCOphth, Bruce A. Noble, FRCOphth, Michael J. Cox, PhD*

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Intraocular lens-capsular bag imaging with ultrahigh-resolution optical coherence tomography: pseudophakic human autopsy eyes

Linnola et al.[1] evaluated the capsule–intraocular lens (IOL) interface and posterior capsular opacification formation in 7 human pseudophakic autopsy eyes with a prototype high-resolution optical coherence tomography (OCT). Nevertheless, in light of the knowledge of applied optics, the design of this in vitro study hardly simulates the in vivo situation, and the reproduction of a similar-quality scan in real life is doubtful.

Optical coherence tomography is a noninvasive imaging technology capable of producing high-resolution images, but it is not a technique without limitations in clinical application. From the law of physical optics, Podoleanu et al.[2] show that variations in lamellar orientation, hydration, and thickness of the cornea can alter the geometry of refraction and have a significant bearing over polarization of OCT images. In scanning the IOL and posterior capsule of a pseudophakic patient, the cornea is the first layer separating air from tissue; if this layer is represented undistorted on OCT, the shape of the deeper layers, including the IOL, is bound to be increasingly blurred as a result of the cumulative effect of different and even unknown indices of refraction up to the depth of interest.[2] These image distortions render the morphometric inference (orientation and shape) of the tissue involved impossible.[2]