CORRESPONDENCE

Total Corneal Astigmatism and Posterior Corneal Surface

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The authors have no financial or proprietary interest in the materials presented herein.

To the Editor:

We read with interest the article by Alpins et al.[1] on corneal total astigmatism measurement in the March 2015 issue.

Our first concern is that they included patients who later proceeded to have refractive laser surgery and therefore the great majority of eyes should have been phakic. This condition introduces a significant confusing factor when comparing the manifest refractive cylinder and the measurements the authors performed, namely the magnitude of the lenticular astigmatism. Qian et al. determined lenticular astigmatism by vector analysis using ocular residual astigmatism (ie, astigmatism not attributed to the anterior corneal surface) and additionally taking in account astigmatism from the posterior corneal surface as measured by a Scheimpflug corneal tomographer (Oculus Optikgeräte GmbH, Wetzlar, Germany).[2] The arithmetic mean of lenticular astigmatism was reported as -0.57 ± 0.33 diopters. Approximately 32% of eyes had a lenticular astigmatism higher than refractive astigmatism. Alpins et al. mentioned that it was not the intention of their study to measure the lenticular astigmatism, but because they used the refractive astigmatism, which includes lenticular astigmatism, as a reference parameter, it could have become a confounding variable affecting the statistical conclusion validity.

However, our greatest concern about the study is that the CorTs method, as originally described, used data from several adjacent concentric Placido rings with a reflection-based topographer (Atlas 9000 corneal topography system; Carl Zeiss Meditec, Jena, Germany). In

this new study, the authors used the Sirius tomographer (Costuzione Strumenti Oftalmici, Scandicci, Florence, Italy), which is a hybrid system (Scheimpflug camera and Placido disk) that obtains the information about posterior cornea from Scheimpflug data and not from Placido ring reflection.[3–5] To derive the magnitude of posterior corneal power from keratometric power, they used an adjustment factor (−8.44) that is based in the keratometric index, a fudge factor that does not indicate the real posterior corneal power because it does not take into account any measurement of the posterior radius of curvature. The authors merely used data for the anterior surface. The great advance of the new imaging systems is precisely the one the authors disregarded: the capability of obtaining reliable posterior corneal surface measurements.[3–5]

Undoubtedly the future points in that direction: determining the true total corneal astigmatism (including actual posterior corneal measurements) on a case-by-case basis using an accurate and validated device. Unfortunately, as Koch indicated in his editorial,[6] we are not sure that we have such a device available, so further studies comparing corneal astigmatism to refractive astigmatism on pseudophakic eyes (precisely to cancel the effect of lenticular astigmatism) using systems to measure the posterior surface of the cornea will help to answer this question. However, refractive astigmatism, even in pseudophakic eyes, as the authors stated in this study, may have other non-corneal contributors to intraocular astigmatism (eg, intraocular lens tilt or decentration). Additionally, measuring differences in alignment of measurements will preclude that total corneal astigmatism measurements, centered on the corneal vertex, will compensate all of the refractive astigmatism.

We are currently performing a study in pseudophakic eyes, determining the total corneal astigmatism as measured by the Sirius tomographer using corneal aberrometry, calculated in the pupil by ray tracing. Preliminary results are encouraging.

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Reply

The authors have no financial or proprietary interest in the materials presented herein.

We thank Drs. Galvis, Tello, Niño, and Parra for their letter regarding our article "Corneal Topographic Astigmatism (CorT) to Quantify Total Corneal Astigmatism."[1]

The first concern raised is that lenticular astigmatism may be a confounding variable in our statistical analysis that might have affected our conclusion. In fact, the analysis was designed specifically to deal with the presence of lenticular astigmatism and other sources of *non-corneal* astigmatism. It is precisely our use of the standard deviation of the ocular residual astigmatism (ORAsd) as our primary measure that allows us to compare corneal astigmatism and manifest refractive cylinder in the presence of other sources of astigmatism. The ORAsd is a calculation of the random error that prevails in any attempt to predict manifest refractive cylinder from corneal astigmatism.

It is useful to conceptually divide this random error into two parts: one part that we affect by changing the corneal measure and one part that is due to factors that we have no control over, including non-corneal astigmatism (lenticular tilt and decentration, retinal tilt, and perceptual components). These factors are present whether the lens is crystalline or pseudophakic.

When we choose the ring range with the minimum ORAsd to generate the corneal topographic astigmatism (CorT), we are effectively choosing the ring range that minimizes the first part of the random error; the second part of the random error including lenticular astigmatism is still present and unchanged.

In their second point, Galvis et al. suggest that an adjustment factor (−8.44) was used to determine the posterior corneal power. We would like to emphasize that we do not apply any adjustment factor to the total corneal power measurements. They are derived from the direct export of the Sirius tomographer (Costuzione Strumenti Oftalmici, Scandicci, Florence, Italy). These total corneal power measurements do incorporate the effect of the posterior cornea via ray tracing.[2] The claim that we "merely used data for the anterior surface" is incorrect. We compared the measured total corneal power measurements to appropriately scaled anterior corneal curvature values. Any other sort of comparison would disadvantage the performance of the anterior corneal power measurements.

An adjustment factor of −8.44 is necessary when comparing anterior and posterior curvature data to manifest refractive cylinder. In this section of the article, we are considering the hypothetical question of how well each ring of data from the anterior, posterior, or total corneal power measurements on its own corresponds to manifest refractive cylinder. To calculate the hypothetical ORA in each case, it is necessary

to scale anterior and posterior corneal curvatures so that they span the same range as would be expected in an equivalent keratometric power. This is exactly the type of adjustment that has been applied historically to anterior curvature measurements to convert them to axial power measurements.

We agree with the comment in the letter that total corneal astigmatism will never fully compensate refractive astigmatism. Indeed, non-corneal sources of astigmatism will still prevail, even when a spherical intraocular lens has been implanted. We argue that it is possible to compare corneal astigmatism and manifest refractive cylinder in a statistically meaningful way, even in the presence of non-corneal astigmatism, and to derive a corneal measure of astigmatism, the CorT, which best corresponds to manifest refractive cylinder.

We appreciate the opportunity to clarify these misunderstandings about our study methodology.

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