Total Corneal Astigmatism Measurement

We read with interest the article by Tonn et al.[1] on corneal astigmatism. At the beginning of the article, the authors indicated that: "Scheimpflug tomographers provide a map of the anterior chamber and therefore a more accurate model of the cornea, its thickness, and posterior surface." Since the anterior chamber is really a space, and not a structure, it is probably clearer to say that Scheimpflug tomographers provide a map of the anterior segment.

In the "Patients and Methods" section, they explained that exclusion criteria included "an astigmatism … less than 39 diopters (D) or greater than 49 D." Those values seem to refer to corneal curvature and not to corneal astigmatism.

The authors denoted that they chose the 3-mm zone of the total corneal refractive power, as measured by the Pentacam, to closely match the standard 15° zone of a keratometric analysis. However, the concept of the standard 15° zone is not clear. Standard manual keratometers acquire data from the reflection of the mires in an annular zone with a diameter ranging approximately from 2.8 to 3.5 mm, depending on corneal radius of curvature. We could not find any reference in the literature to a standard 15° zone with regard to keratometry.

In the "Results" section, the authors referred to the orientation of both corneal anterior and posterior astigmatisms. Astigmatism can be written in positive or negative cylinders; therefore, the direction (axis) of the astigmatism will have opposite meanings: in the case of keratometric astigmatism, since the cornea is a positive lens, the axis of positive cylinders will indicate the steepest meridian, while the axis of negative cylinders will indicate the flattest meridian. In several instances, the authors referred to the alignment of the astigmatism assuming that the reader understands that a positive cylinder is used. However, in many regions (like in Latin America), ophthalmologists usually write astigmatism using a negative cylinder notation. It would be clearer to say: "if the steepest meridian on the anterior surface was vertical" than to say: "if anterior astigmatism was vertical"; and to say: "the axis of steepest anterior corneal meridian" rather than: "the axis of anterior astigmatism."

In the second paragraph of the "Discussion" section, the authors indicated: "In most cases, posterior curvature created against-the-rule (ATR) astigmatism, due to its negative corneal power and vertical alignment." Later, in the same section, they partially explained this apparent paradox. We think that, as posterior corneal astigmatism is rather a new topic of discussion among clinicians (due to the recent increase in the use of toric intraocular lenses and the availability of evolving technologies for measuring posterior corneal curvature), it deserves a more robust clarification. The situation can be easily grasped if it is envisaged that since the posterior corneal surface has a negative power, the steeper the curvature of a given meridian, the more negative the power of that posterior corneal meridian. Therefore, when the steepest posterior corneal meridian is aligned vertically, it will subtract more power along the vertical meridian of the whole optical system than the power subtracted by the horizontal posterior corneal meridian along the horizontal meridian of the optical system. Thus, using traditional refraction terminology, it is acting like an against-the-rule anterior corneal astigmatism.

The finding that only 59% of eyes with steepest anterior corneal meridian aligned horizontally had the steepest posterior corneal meridian aligned vertically is very important, because it indicates that, as the authors concluded, it might be inaccurate to apply a simplified nomogram as has been suggested.[2] Further studies are needed to clarify this discrepancy. Unfortunately, a gold standard for measuring posterior corneal astigmatism remains elusive and despite advances in corneal imaging (Scheimpflug tomographers, three-dimensional anterior segment optical coherence tomography), we still lack validated ways to accurately measure posterior corneal astigmatism on a given eye.[3] In a clinical study with 41 eyes that underwent toric intraocular lens (IOL) implantation, Koch et al.[2]—using a combined Placido's disk–dual Scheimpflug system (Galilei tomographer, Ziemer, Port, Switzerland)—found mean prediction errors of 0.57 D in the with-the-rule group and 0.12 D in the ATR group even using dual Scheimpflug technology.

In the "Discussion" section, the authors stated: "With IOL selection based on $CA_{Sim\text{-}K}$, 5.8% had an error of magnitude of more than 0.50 D and 20.1% had an alignment error of more than 10°." As the 3818 eyes included in the study did not actually undergo toric IOL implantation, it would be clearer to say: "If the eyes included in this study had had a toric IOL selection based on $CA_{Sim\text{-}K}$, then 5.8% would have had an error of magnitude of more than 0.50 D and 20.1% an alignment error of more than 10°." Additionally, in those predictions, other factors should be taken in account (e.g., surgically induced astigmatism, predicted versus actually induced, and effective lens position).[4]

In the future, as Koch[3] recently indicated, accurate measurement mean posterior corneal power, as measured by accurate technologies, will also improve precision in determining spherical equivalent power of any intraocular lens, especially in eyes that have undergone corneal refractive surgery. As known, currently total corneal power used in biometric formulae is calculated using only the anterior radius of curvature and a fudge factor (the keratometric index, usually 1.3375), with the assumption that there is a fixed ratio between the anterior and posterior curvatures. Those emerging devices will enable ophthalmologists to accurately measure both posterior corneal astigmatism and posterior corneal power (spherical equivalent) to include those data in new biometric formulas that will make no assumptions about posterior corneal power (as currently used formulas do).

Undoubtedly, we still have a long way to go to get truly reliable posterior corneal measurements and to determine the best way to analyze those data (there are several different complex vectorial methods available, which are not either straightforward or universally accepted)[5–9]; but at least we have taken the first crucial steps in the right direction, and clinical studies such as the one performed by Tonn et al.[1] will help us reach the goal of better results when implanting toric intraocular lenses. However, as Alpins et al.[10] recently stated, posterior corneal astigmatism does not seem to be the only significant factor in the equation of final manifest refractive cylinder and noncorneal contributors likely include other sources of intraocular astigmatism (in pseudophakic eyes, IOL tilt or decentration) and processing in the visual cortex. Moreover, differences in alignment of refractive measurements and corneal astigmatism measurements (the former referenced to the center of the pupil, and the latter to the corneal apex), will also affect the accuracy of the results.

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