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CorT an accurate, consistent measure of corneal astigmatism

Corneal topographic astigmatism outperforms manual keratometry, simulated keratometry, corneal wavefront and paraxial curvature matching.


Amar Agarwal

The measure of corneal astigmatism magnitude and its meridian has become increasingly important with toric IOLs, femtosecond laser limbal relaxing incisions and high patient expectations to be independent of spectacles. Noel Alpins, my guest columnist in this issue, will explain this in detail.

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The technology available to measure corneal astigmatism is multiple. It includes manual keratometry, automated keratometry (Lenstar from Haag-Streit and IOLMaster from Carl Zeiss Meditec), simulated keratometry (topographers), total corneal astigmatism (tomographers) and corneal the refractive cylinder. The refractive cylinder includes the optical elements of the eye as well as the visual cortex because the patient's non-optical perception during a subjective refraction is used to tell the practitioner the patient's preference.

The subjective refraction is based on all the light entering the pupil from both straight ahead and peripherally; therefore, a greater area of the cornea than the pupil size alone under all lighting conditions would be more advantageous than the limited calculations of corneal astigmatism in the central zones commonly used.

Corneal topographic astigmatism (CorT) is calculated using all the valid data that is captured during topography/tomography (Figure 1). This is particularly important in irregular corneas in which the Sim K calculation measured at the 3-mm corneal zone may have been based on an irregular or less than smooth section that is not representative of the whole cornea. Furthermore, the Sim K calculation at the 3-mm zone is not consistent for all corneas because the "3

CorT anterior

The study investigated the Carl Zeiss Meditec Atlas 9000 topographer for anterior CorT. Five different measures of corneal astigmatism were evaluated: manual keratometry (Man K); Sim K; corneal wavefront (CorW); paraxial curvature matching (PCM); and CorT.

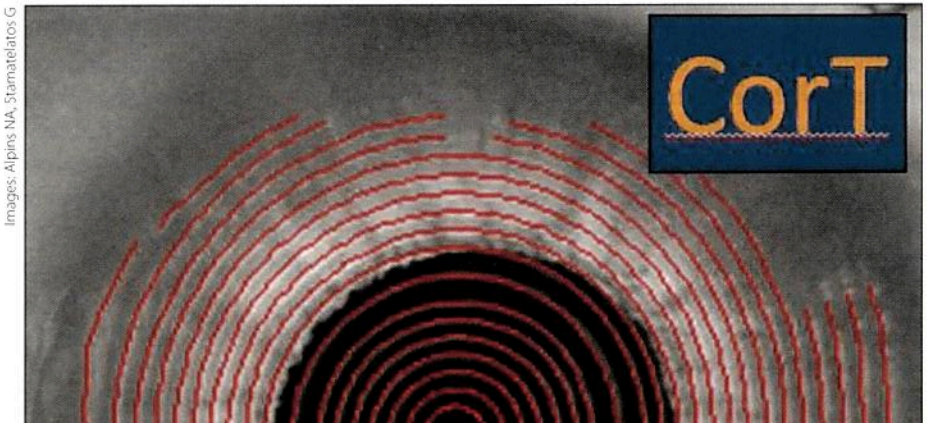
Four hundred eighty-six eyes were examined using the Atlas 9000 topographer, all of which were virgin eyes that were assessed preoperatively for excimer laser surgery.

The key parameter used to compare the various measures of corneal astigmatism was the standard deviation of the ORA (ORAsd), which is a measure of the variability of the match between corneal astigmatism and manifest refractive cylinder. A low ORAsd indicates that the corneal astigmatism matches the refractive cylinder consistently and with minimum variability.

The mean of the ORA magnitudes (ORAmean) is also of clinical relevance. A low ORA magnitude indicates that the corneal astigmatism is well aligned in meridian and magnitude to the corneal plane manifest refractive cylinder, effectively representing the total refractive power of the eye.

The CorT was found to have the smallest variability of the ORA compared with the other measures of corneal astigmatism (Figure 3).

The most accurate rings for the Atlas topographer with the lowest standard devia-



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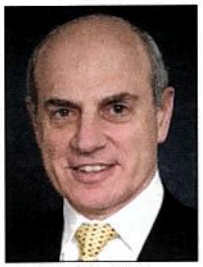
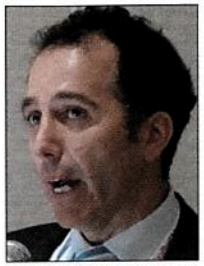


Noel A. Alpins



George Stamatelatos

wavefront (aberrometry). In addition, there are sophisticated toric IOL calculators available to obtain the most accurate toric IOL power using many parameters such as axial length, anterior chamber depth and personalized IOL constants.

The calculated parameters for corneal astigmatism involve the measurement from a specific but differing area of the cornea and in many cases only the anterior cornea. For simulated keratometry (Sim K), this is around the 3-mm region, for manual keratometry at the 3- to 4-mm zone, for the IOLMaster at six points around the 2.5-mm zone, and for the Lenstar 32 markers on two concentric rings.

Topography systems measure the radius of curvature of most of the entire cornea with the exception of eyelid cover superiorly and tear film inferiorly. Using all this information rather than the limited data measure from one particular zone on the cornea provides much more information as to the overall amount of astigmatism on the cornea and its orientation.

A good benchmark measure of how much astigmatism a particular eye has is mm" varies depending on whether a steep or flat cornea is measured; in steep corneas, the Sim K will be calculated using data acquired from a region that is less than 3 mm in diameter, and in a flat cornea, from a region that is more than 3 mm.

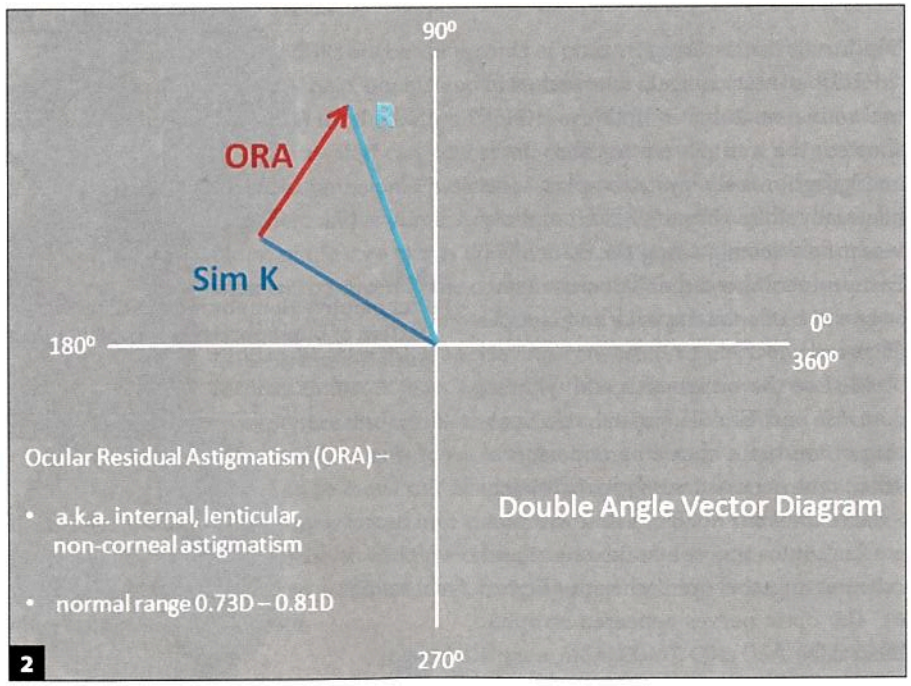
Any measure of corneal astigmatism, regardless of how accurate it may be, will still not be equivalent to the refractive cylinder in magnitude and/or orientation in most cases because there is lenticular astigmatism, retinal tilt and the non-optical component of the visual cortex to consider. The vectorial difference between the refractive cylinder (at the corneal plane) and the corneal astigmatism is known as the ocular residual astigmatism (ORA) and has a magnitude and axis expressed in diopters and degrees (Figure 2).

CorT provides a consistent measure of corneal astigmatism for both regular and irregular corneas. This can then be used in the calculation of the most appropriate toric IOL in cataract surgery or the placement of the center of the arc in limbal relaxing incisions.

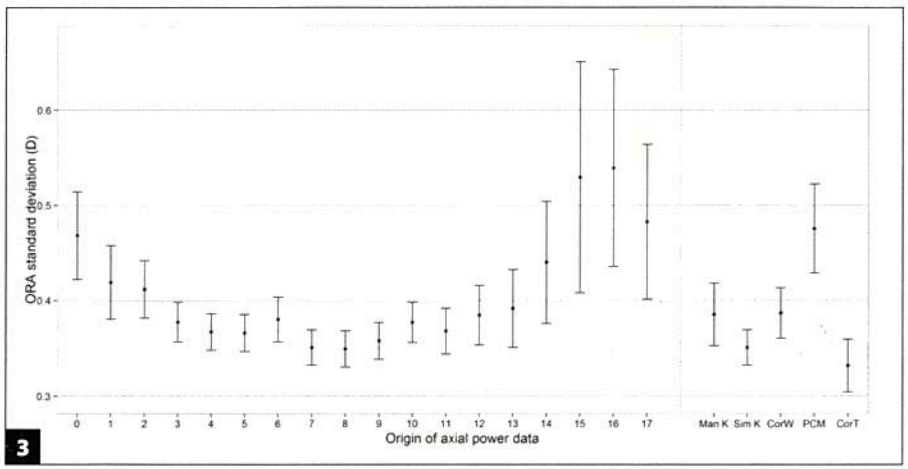
The CorT value is calculated using a summated vector mean of the astigmatism values determined from all the measured data of corneal curvature/power exported from the topography acquisition.

The astigmatism for various corneal zones is determined using a best fit spherocylinder for the data. What particular zones are used is specific for each different topographer by comparing contiguous sets of zones to determine the minimum ORA.

CorT is calculated using all the data captured during acquisition.



ORA, the vectorial difference between corneal astigmatism and refractive cylinder (at the corneal plane), is expressed in diopters.



ORA standard deviation estimates ±2 standard errors vs. ring data for the Atlas topographer. The CorT has the minimum standard deviation compared with other measures of corneal astigmatism corresponding to less variability of the ORA.

tions were found to be rings 3 to 12 inclusive.

The CorT was also found to have the smallest mean ORA magnitude compared with the other measures.

CorT total

The power of the posterior cornea and its effect on the anterior corneal power to obtain a total corneal power has been a topic of discussion in recent times.

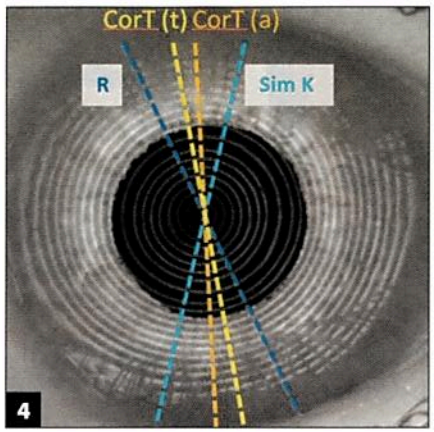
The CorT was again investigated in another study to determine whether the data obtained from the anterior and posterior cornea resulted in a more accurate CorT (termed CorT total) compared with the CorT based on anterior corneal data alone.

The Sirius tomographer (Costruzione Strumenti Oftalmici), which uses the combination of a Placido disc and a rotating Scheimpflug camera to measure the anterior and posterior corneal surfaces across the whole cornea, was used to capture the data.

Measurements were made at 240 points on 30 evenly spaced concentric rings, with diameters ranging from 0.4 mm to 12 mm. Total CorTs were derived for each ring, and consequently a summated vector mean of all the total CorTs was calculated to give the most accurate estimation of the total corneal power.

Five hundred twenty-six virgin healthy eyes were included in the study, again all of which were assessed preoperatively for excimer laser surgery.

Total corneal power measurements (incorporating anterior and posterior cornea) better matched the manifest refractive cylinder (ORA mean of 0.53 D) than using anterior corneal power measurements alone (ORA mean of 0.64 D) and a lower variability (0.32 D ORAsd for CorT anterior vs. 0.30 D for CorT total). These results were statistically significant. Hence, the total CorT was a more reliable measure of corneal astigmatism than Sim K, Man K and CorW.



The CorT total is closer in magnitude and orientation to the refractive cylinder than CorT anterior and Sim K.

The ring ranges for CorT total describe an inner diameter of 2 mm and an outer diameter of somewhere between 4 mm and 6 mm; these correspond to a ring range of 5 to 13 in the Sirius tomographer.

It is important to note that the manifest refractive cylinder is not accounted for completely by the corneal astigmatism (even if posterior cornea is included). Despite using the latest technology and repeating measurements to reduce error, our data showed a systematic mismatch between the total CorT and the manifest refractive cylinder of 0.53 D against-the rule. An additional factor to a non-zero ORA in the data was where the measurement was being taken: corneal apex for topography and pupil center for manifest refraction. Alignment of these parameters would lead to a reduced but still a non-zero ORA.

Planning surgical procedures

A consistent corneal measure of magnitude and orientation can reassure the surgeon of the targeted astigmatic treatment and meridian. The CorT parameter can be used with confidence when planning such surgical procedures that correct for corneal astigmatism.

CorT can be used for regular and irregular corneas as an accurate parameter for the total astigmatic power of the cornea and its meridian. The CorT derived from total corneal power measurements better matches manifest refractive cylinder than the CorT derived from anterior corneal power measurements (Figure 4). This means that it also outperforms Sim K, Man K, CorW and PCM.

The CorT anterior and total parameter is currently available using the iAssort software on the leading topographers and tomographers. These include the Sirius tomographer, the Oculus Pentacam, the Ziemer Galilei, the Atlas and the Nidek OPD Scan-III. OSN

See references online at Healio.com/OSN.

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Disclosures: Alpins reports a financial interest in Assort Surgical Management System. Agarwal reports no relevant financial disclosures.