Corneal Topographic Astigmatism Measurement

Noel Alpins, FRANZCO, FRCOphth, FACS
Medical Director NewVision Clinics, Australia

George Stamatelatos, BScOptom
Senior Optometrist NewVision Clinics, Melbourne, Australia

The accurate measurement of corneal astigmatism has been the topic of many recent presentations due to the increasing prevalence of toric IOLs and femtosecond LRI technology. These procedures benefit from clear defined and accurate corneal astigmatism measurements. The alignment of the IOL and LRI with the steepest corneal meridian together with the selection of the appropriate power and degree of arc are key factors in determining patient satisfaction.[1]

Many surgeons rely on corneal astigmatism measurements from a number of instruments. These can include the Zeiss IOL Master, Haag-Streit Lenstar LS900, topography and manual keratometry. From these multiple readings a single magnitude and meridian must be chosen to best represent the corneal shape, which can be challenging as magnitudes and meridian usually vary between devices. It is important to remember that each of these instruments measures the corneal astigmatism in a slightly different manner.

Topographers display a simulated keratometry (Sim K) value based on data obtained from the 3mm region of the anterior cornea – this in itself can vary depending on whether a steep or flat cornea is being measured. For a steep cornea the Sim K measurement will be determined from a different more central region of the cornea to that of a flat cornea.

The Sim K is determined using data from one Placido ring or from a Scheimpflug camera. In a significantly irregular cornea the limitation of the asymmetrical and/or non-orthogonal data collected can lead to inaccurate measurements.

IOLMaster measures the keratometry at 2.5mm corneal diameter using 6 points measured 5 times with each acquisition. Again an irregular cornea will present a somewhat imprecise and variable measure of the magnitude and orientation of corneal astigmatism.

Lenstar has more measurement points and uses a 32 pattern marker on two concentric rings (1.65 and 2.3mm in diameter). This instrument can also provide Placido topography of the central 6mm optical zone.

The *Manual Keratometer* measures corneal astigmatism at 3.2mm diameter using mires projected by light onto the cornea. Since each instrument measures corneal astigmatism in a different manner and position of the cornea, one should not expect to obtain the same value for the one eye from several devices. What is of paramount importance is consistency – so that pre and postop measurements of corneal astigmatism are performed using the same instrument and where possible the same operator, to minimize any potential variability.

The corneal astigmatism measurements provided by the currently used instruments mentioned are taken at particular points on the cornea. A new parameter known as corneal topographic astigmatism (CorT) can be calculated using all the raw data obtained by the topography system – not limited to the 3mm zone of the cornea **(Figure 1)**.[2] In this study anterior topographic data were captured using an Atlas 9000 system (Carl Zeiss Meditec). The study assessed 486 virgin eyes with an age range of 19-64 years. A best fit sphero-cylindrical curve was fitted to the data and a vector mean of the astigmatism values was obtained for the whole cornea. The CorT was found to correspond more accurately in magnitude and orientation to manifest refractive cylinder than any of Sim K, Manual Keratometry, Corneal Wavefront (CorW) and Paraxial Corneal Matching (PCM) **(Figure 2)**. The ocular residual astigmatism (ORA)[3-6] magnitude and its standard deviation were used to assess how closely each measure of corneal astigmatism matched the manifest refractive cylinder and its variability.

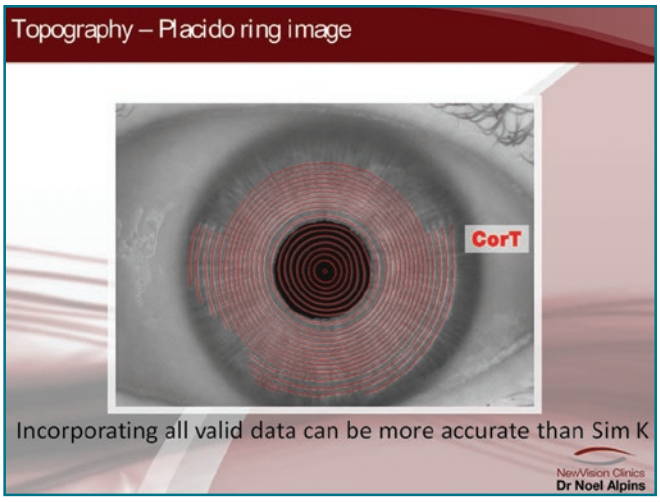

Figure 1. Incorporating all the valid topography ring data captured into the calculation of corneal astigmatism can be more accurate than Sim K which is based on one Placido ring.

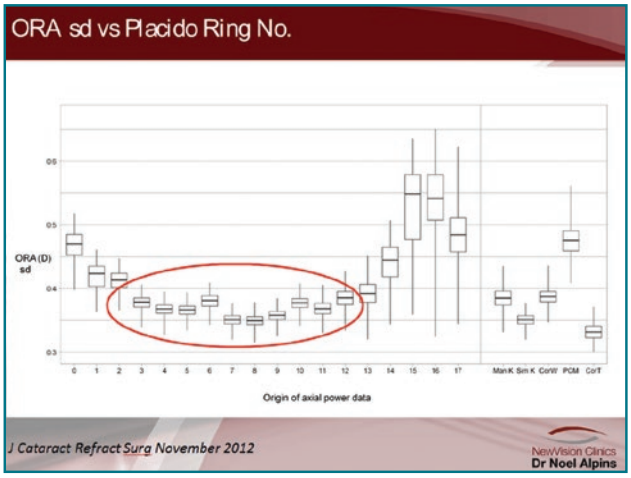

Figure 2. The best range of Placido rings to generate CorT by examining the standard deviation of the ORA mean was number 0 to 17 in the AtlasTM 9000 (Carl Zeiss Meditec). CorT has the smallest variability of the ORA compared with other measures of corneal astigmatism which included Sim K, Manual K, Corneal Wavefront (CorW) and paraxial corneal matching (PCM).

The ORA is defined as the vectorial difference between the corneal astigmatism and the refractive cylinder at the corneal plane and is expressed in diopters and axis **(Figure 3)**. Furthermore, CorT provides a consistent measure of corneal astigmatism (magnitude and orientation) for regular and irregular corneas which can be introduced into toric IOL and LRI planning to better correct astigmatism instead of the keratometry measures obtained from several currently used instruments. As the CorT is based on multiple data points of the whole cornea, the impact of any single outlier is lessened by gaining an average of all the rings instead of relying on just one.

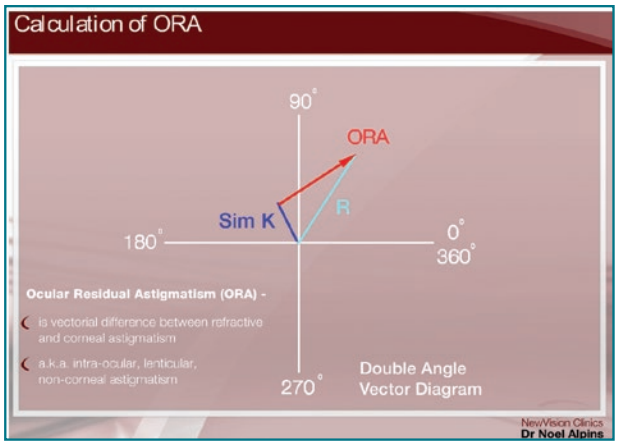

Figure 3. Calculation of the ORA to ascertain which corneal astigmatism measurement was better matched to the manifest refractive cylinder.

The calculation of CorT will be implemented into topographers in the near future using the iASSORT® software. This will include a CorT value of the total corneal power including the posterior cornea in the topographers that are able to measure it.

Furthermore, by dividing the cornea into two hemi divisions, two CorT values can be calculated. These two CorT values, one for the superior cornea and one for the inferior can then provide a vectorial measure of corneal irregularity known as topographic disparity (TD).[7] In this way, a standardized parameter can be compared across all topography systems for corneal irregularity instead of the various individual measures currently that are different for each system. Using CorT, consistent values are obtainable for surgical procedures and analysis for both regular and irregular corneas undergoing surgery. This also enables nomogram refinement to be more precise and result in better outcomes.

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