Topographic disparity: a useful new measure of irregular astigmatism

Topographic disparity takes over what corneal topography overlooks.

by Noel A. Alpins, FRACO, FRCOphth, FACS
Special to OCULAR SURGERY NEWS

Editor's note: This article, by Noel A. Alpins, FRACO, FRCOphth, FACS, is the fifth and last in a series of articles that OCULAR SURGERY NEWS *has published in its Refractive Surgery Section.*

Thanks to the wonderful advance of corneal topography, most ophthalmologists by now are familiar with the various patterns that are manifested by naturally occurring irregular astigmatism. The two steep corneal hemimeridians 180° apart in regular astigmatism may be separated by less than 180° (called non-orthogonal). Of the two steep hemimeridians, one may be significantly steeper than the other (called asymmetric). Corneal topography makes the condition readily apparent. However, corneal topography systems at this point overlook a useful new vector tool called topographic disparity (TD).

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TD, calculated using vector analysis, is a single dioptric value that quantifies the amount of difference between the two hemimeridians of a cornea with irregular astigmatism. TD can only be calculated, not measured, as is true of all vector values. I believe it has important applications both in quantifying irregular astigmatism and in evaluating the success of certain refractive surgical procedures.

My vector analysis approach to astigmatism analysis has been described in a number of articles published since 1993. The calculations have been performed by the ASSORT program and Designer Cornea module, in which I have a financial interest.

Double Angle Vector Diagram (DAVD)

The magnitude of the TD is the distance, expressed in diopters, between the displays of superior and inferior topographical values on a 720° double-angle vector diagram (DAVD). As we are performing separate analyses of astigmatism that lie on orientations between 0° and 180°, called the superior hemidivision, and also between 180° and 360°, called the inferior hemidivision, the DAVD must necessarily extend past 360° and undergo a second revolution to 720°. This complexity demonstrates the need to display vectors (after their calculation on a DAVD) at their actual orientation on a polar diagram that does not extend beyond 360°. This enables direct viewing of the vector changes in relation to the cornea.

By convention, the axis of the TD is defined as half the orientation value of the vector from superior to inferior on the DAVD. Figure 1 shows an astigmatism and surgical vector diagram of an eye with irregular astigmatism. Figure 2 is the DAVD of the same eye, displaying the TD. The targeted change (target induced astigmatism, or TIA) can take a number of approaches described previously according to the surgeon's preferences and the needs of the individual patient.

Irregular astigmatism

My article on irregular astigmatism, "The treatment of irregular astigmatism," includes a small study I did in order to determine the TD values in patients with correctable astigmatism and myopia prior to their undergoing refractive correction and any statistically significant relationships TD may have to other prevalent variables.

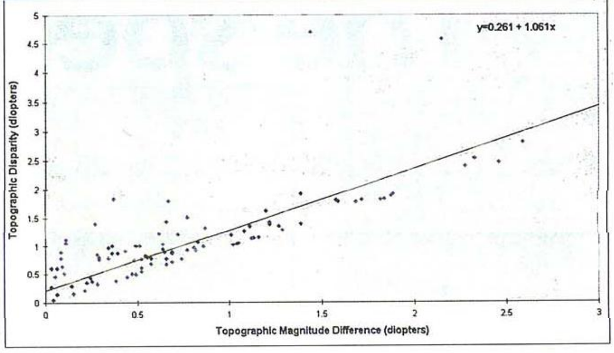
We determined the TD in the first treated eye of 100 consecutive patients prior to their receiving excimer laser photoastigmatic keratectomy between June 1992 and October 1995 at my facility. Corneal topography values were determined by the simulated keratometry values using the topographic modeling system.

The mean TD in the sample group was 1.10 D±-0.08 (range 0.04 D to 4.7 D). The TD exceeded 1 D in 43 patients. Because about 70% of our refractive surgery patients require some amount of astigmatic correction, I interpret these results to indicate that irregular astigmatism is very prevalent in the population of our patients, if not the population in general. Not one patient was "perfectly" symmetrical. It remains to be seen at what level TD becomes a "clinically significant" impediment to good vision. At least the yardstick now exists to examine this with clarity and consistency.

Figure 3 is a scatterplot showing the strong relationship that exists between the TD and the difference between superior and inferior topographic magnitude in the 100 eyes mentioned above ($P < .0001$), as one might expect. Similar analysis also revealed a direct relationship between TD and the nonorthogonal angle subtended between the two topography semimeridians ($P < .0001$).

The most surprising finding was this: the greater the TD, the greater the ocular residual astigmatism, a measure of the difference between topography (simulated keratometry) and refractive astigmatism ($P < .0001$). This finding is very relevant, particularly as there have been so many proposed explanations to account for the differences in corneal and refractive astigmatism.

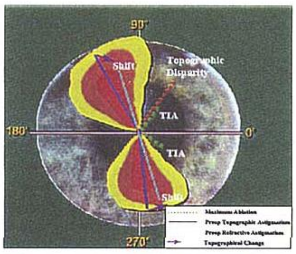
Topographic disparity magnitude vs. difference between superior and inferior topographic magnitude values



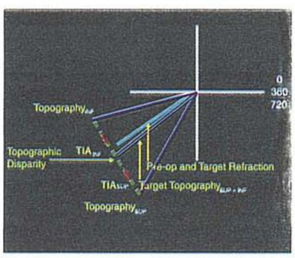
New planning tool

The previous article in this series described a number of approaches to irregular astigmatism calculable with vector planning according to the surgeon's preference and the patient's requirements. Two of those approaches utilize minimum astigmatic treatment equal to the TD and most do not reduce the overall astigmatism of the cornea – they only rearrange it.

In the first approach utilizing TD, the surgeon may decide to regularize the corneal shape, thereby offering the potential of improved uncorrected visual acuity or best corrected visual acuity with no change in refractive astigmatism. The treatment to regularize the cornea is at a minimum and is equal in magnitude to the TD. A patient thus treated would not require a change in spectacles but could be expected to have a better quality of vision (the smooth versus the rippled window).



Astigmatism and surgical vectors are superimposed over their respective positions on the cornea. The treatment in this case is to achieve orthogonal symmetrical astigmatism and no change in refractive astigmatism.



The same eye as above, depicted on a double-angle vector diagram (DAVD). The magnitude of the TD is the dioptric distance between the superior and inferior topographic values.

In the second approach utilizing TD, an orthogonal symmetrical cornea can be achieved by treating only one hemidivision. Based on individual considerations of what is favorable or unfavorable, the surgeon can move the less favorably oriented semimeridian to coincide with the more favorably oriented semimeridian or can move the other hemimeridian in the opposite direction, if preferred. In both cases, the treatment is at a minimum and equal to the TD.

Application potentials

TD offers a way to quantify irregular astigmatism in a manner not previously available. Studies utilizing TD could help define what is clinically significant TD by both magnitude and axis. TD could be used to evaluate the results of spherical refractive surgical procedures or procedures aimed at correcting only near-regular astigmatism (that is, by removing from the evaluation of those procedures outlying patients who have a TD greater than some predetermined amount). Our understanding of the effectiveness of both spherical and astigmatic refractive procedures would be significantly enhanced if patients could be grouped according to their preoperative TD measurements.

TD also has potential in describing and treating irregular astigmatism caused by injury or prior ocular surgery. Whenever a magnitude and an axis can be assigned to each of the separate hemidivisional astigmatism, TD can be calculated. As in the case of naturally occurring irregular astigmatism, TD offers potential analytical and treatment applications for irregular astigmatism of this type and quantifies the least amount of treatment to regularize the cornea by moving one or both hemimeridians.

To my knowledge, no currently available corneal topography system provides an aggregate simulated keratometry value for each side of the cornea. It would be a great benefit, in my opinion, if corneal topography machines provided this information, and we then would be able to routinely calculate TD and display it in their respective readouts. I think the clinical utility of such a feature would quickly become apparent. As the situation now exists, TD represents useful and reliable information that is simply being overlooked.

Perhaps most significant of all, TD offers a single number that quantifies the amount of irregular astigmatism on a cornea. Such a measure would allow surgeons to communicate simply and quickly with each other about an otherwise complicated situation. ■

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