The treatment of irregular astigmatism

OCULAR SURGERY NEWS presents the fourth in a series of articles on astigmatism analysis and correction.

Although irregular astigmatism is usually considered in association with prior ocular surgery or injury, it is most often encountered in its naturally occurring form. This widely prevalent form of irregular astigmatism comes in various configurations: the two steep hemimeridians, 180° apart in regular astigmatism, may be separated by less than 180° (called nonorthogonal); and of the two steep hemimeridians, one may be significantly steeper than the other (called asymmetrical).

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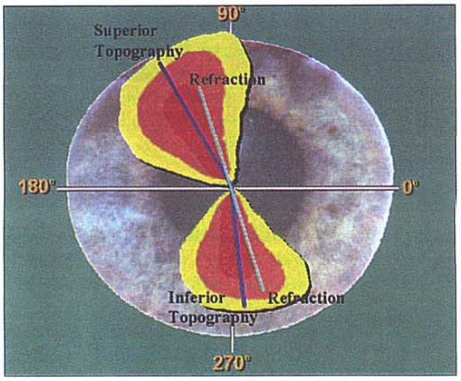
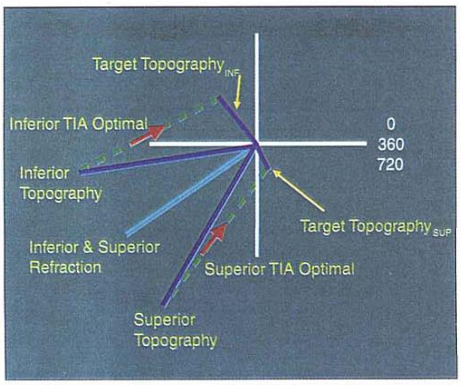
The vector analysis method that I described for regular (symmetrical and orthogonal) astigmatism also can be used to analyze independently the changes in the two hemimeridians of irregular astigmatism. This allows the surgeon to calculate the necessary laser treatment for the two separate halves of the cornea – an important capability as refractive lasers advance to the point where they are able to treat discrete sectors of the cornea. My vector analysis approach is described in detail in a number of articles published since 1993 (see references).



Polar astigmatism and surgical vector diagram shows parameters as they would appear schematically on an eye with irregular astigmatism.



A double-angle vector diagram (DAVD) allows rectangular coordinates to be used in depicting optimal treatment as calculated separately for each corneal hemidivision.

Vector planning allows the surgeon to take a number of different approaches to treating irregular astigmatism, from "sphericizing" the cornea, to realigning one or both hemimeridians in order to "regularize" the irregular astigmatism without necessarily reducing the overall astigmatism of the cornea. The approaches are described below. Regularizing irregular astigmatism is likely to improve the quality of vision just as a new, high-quality window provides a better view than the rippled glass of an old window, or a smooth mirror casts a better reflection than a distorted mirror.

Double the fun

Figure 1 is a polar astigmatism and surgical vector diagram depicting astigmatism values schematically in an eye with irregular astigmatism. Figure 2 is a double-angle vector diagram (DAVD) through which vector analyses can proceed. This particular analysis is for optimal treatment to each corneal hemidivision, described later in greater detail.

As we are analyzing astigmatism independently that lies on orientations between 0° and 180° (which we call the superior hemidivision) and also between 180° and 360° (which we call the inferior hemidivision), the DAVD must necessarily extend past 360° and farther on to 720°. This renders the display of vectors at their actual (not doubled, as suggested by some authors) angles – an essential step to avoid unnecessary complexity, and to enable the visualization of the treatments and changes directly related to the eye.

Reduction of astigmatism

In practice, the superior and inferior hemidivisions will always share a common refractive value; obviously, the eye as a whole can only volunteer one refractive astigmatism value. However, when there are two distinct preoperative topography values on each hemidivision, there will be differing calculated target values of both refractive and topographical astigmatism after asymmetrical treatment.

When assuming the cornea to be regular for symmetrical treatment as is currently practiced, I have described the optimized treatment of the two sides of the cornea utilizing both the simulated keratometry and the refractive value in the planning process. In the same way for an irregular cornea, the separate orientations of these upper and lower targets for the two differing hemidivisions result in different emphases being placed on eliminating refractive or corneal astigmatism in the separate asymmetrical surgical plans.

Applying optimal treatment to each hemidivision. Figure 2 shows the separate superior and inferior topography targets by applying the target induced astigmatism (TIA) superior (optimal) to the superior cornea and the TIA inferior (optimal) to the inferior cornea. In this case, the closer the target astigmatism approaches against the rule, the more the surgical plan emphasizes topography to achieve a spherical cornea in that hemidivision. The goal is to separately reduce astigmatism maximally in both hemidivisions.

Regularization of astigmatism

The method as described also allows the calculation of separate hemidivisional targets in order to reshape the cornea and customize goals in a number of ways, according to the surgeon's preference and the patient's requirements:

Achieving orthogonal symmetrical astigmatism with no change in refractive astigmatism. In the presence of nonorthogonal or asymmetric astigmatism (or both), the surgeon may decide to regularize the corneal shape, thereby offering the potential of improved uncorrected visual acuity or best corrected visual acuity. The approach provides treatment parameters that would result in no change in spherical equivalent or overall refractive status of the eye. (In this case, the total astigmatic treatment is at a minimum and equal to the topographic disparity, which is described in the next article in this series.) A patient who wore spectacles would need no change in spectacle prescription after this type of treatment, but might be expected to have a better quality or even quantity of vision. Indeed, one could propose the establishment of "See Better" clinics for people who would benefit from this approach, even if they do not require spectacles at all for overall vision.

Achieving orthogonal symmetrical astigmatism by shifting one topography semimeridian. The correction of irregular astigmatism to produce an orthogonal symmetrical state can be achieved by treating only one hemidivision of the cornea. Based on individual decisions of what is favorable or unfavorable, the surgeon can move the less favorably oriented semimeridian to coincide with the more favorably oriented semimeridian. (Again, treatment is at a minimum and is equal to the topographic disparity.) As with the prior example, the rationale is to achieve a better quality of vision.

Achieving orthogonal symmetrical astigmatism in a preferred orientation. The TIA can be set to change the prevailing refractive or topographic astigmatism for any desired or favorable orthogonal symmetrical target. A nominated target might be, for example, 0.75 D with-the-rule in both superior and inferior hemidivisions, requiring different treatments in each half of the cornea to achieve this common goal.

Achieving corneal sphericity or any desired corneal astigmatic configuration. The method allows analyses of astigmatic change in its separate component parts on each hemidivision of the cornea. This holds true regardless of the mechanism of change: surface or intrastromal ablation, laser thermal or radio frequency keratoplasty, astigmatic keratotomy or mechanical device that changes corneal shape. The separate hemidivisional targets can readily be set to obtain a spherical cornea, if the surgeon chooses, in the knowledge that some refractive astigmatism is likely to remain.

The future

Manufacturers appear on track to link corneal topography to scanning excimer lasers capable of applying customized treatments to various parts of the cornea. I believe my method provides a way to merge diagnostic (topography), therapeutic (laser) and analytic (vector planning) functions into an integrated refractive surgical approach. This marriage and integration would allow planning, performance and analysis of refractive procedures using one comprehensive computerized instrument as opposed to three or more, as is currently the case. ■

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