Flattening, steepening and torque are crucial points in astigmatism surgery

Ocular Surgery News presents the second in a series of articles on astigmatism analysis and correction.

by Noel A. Alpins, FRACO, FRACO (Ophth), FACS

Special to Ocular Surgery News

Editor’s note: This article, by Noel A. Alpins, FRACO, FRACO (Ophth), FACS, is the second in a series of articles that Ocular Surgery News plans to publish in its Refractive Surgery column. The general goal of astigmatism surgery is to flatten the cornea at its steepest meridian, steepen the cornea at its flattest meridian, and create a cylinder of the intended degree and axis in the meridian between.

The technique utilizes vector analysis and certain metrics that I have described in previous papers (see references for the references at the end of this article). The approach can be used for both incisional (テーブルカット) and non-incisional (輪切術) refractive procedures. My calculations have been performed using the AOSART program, in which I have a financial interest.

The principal meridians of flattening, steepening and torque in relation to the preoperative astigmatic meridian: astigmatism treatment is based on refractive astigmatism values in eyes exhibiting an axis difference between topographic and refractive astigmatism, and when using my “optimal approach” described in the next article in this series where the treatment axis does not coincide with either resection or topographic meridian.

Flattening, steepening and torque also are useful in a number of other situations:

- To determine the functional effect of incisional or ablative procedures.

- To determine a treatment’s steepening effect at the preoperative steep meridian.

- To determine the net astigmatism change at the polar axes (with-the-rule and against-the-rule).

Defining terms:

- The AOSART program fills in a number of terms including those described in the previous article.

- Target induced astigmatism (TIA): The change in astigmatic parameters produced by laser surgery.

- Steepening (by magnitude and axis) the surgeon intends to induce.

- Surgically induced astigmatism (SIA): The amount and axis of astigmatism the surgeon actually induces.

- Correction index (CI): The ratio of the SIA to the TIA (what the surgery actually induces versus what the surgeon was meant to induce), calculated by dividing SIA [actual effect] by TIA [target effect]. The CI is preferably 1.0 (it is greater than 1.0 if an overcorrection occurs, and less than 0.8 if there is an undercorrection).

- Angle of error (Anger): The angle described by the vector of the achieved correction versus the intended correction. The Anger is positive if the achieved correction is on an axis clockwise versus the intended axis, and negative if the achieved correction is counterclockwise to its intended axis.

Mild Magnitude of error (MDE): The arithmetic difference between the magnitudes of the SIA and the TIA. The MDE is positive for overcorrections and negative for undercorrections.

Effect of Off-Axis Treatment

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Missed treatment:

In Figure 3, which is derived from vector analysis, the FI becomes smaller as a function of increasingly missed treatment, bypassing it to another meridian. However, the SIA is unaffected and thus the CI also is unaffected. Most authors agree that the most interesting effect is 45°, the flattening effect at the intended meridian becomes zero, that is, no measurable change in astigmatism has occurred at the treatment meridian. Beyond 45°, the FI becomes negative and so an increase in astigmatism has occurred.

Accordingly, Figure 3 does not conform to the near linear relationship suggested by other authors. Vector analysis indicates that, at 15° off axis, 35% of the flattening effect is lost. Others have suggested that up to 50% of effect is lost at 15° off axis, which severely overstates the loss of flattening effect by misplaced treatment. Vector analysis indicates that treatment would need to be 30° off axis to yield a 50% loss of effect.

If the SIA is unaffected and yet does not reduce astigmatism by flattening the cornea at the preoperative meridian in the intended manner, how is it being spent? In fact, it is affecting the remaining preoperative astigmatism by rotating or compounding the meridian. So for any astigmatism change that becomes increasingly off axis, as the flattening effect diminishes, the SIA becomes more negative, as it becomes more positive, it introduces in astigmatism. In addition to this, a pure torque force has a tendency to increase the remaining astigmatism that is rotating.

Comprehensive understanding:

In general, there are three indices that examine the relationship of three vectors to the treatment vector (the TIA) and complete a comprehensive approach to astigmatism analysis: the CI, which is the overall astigmatism correction achieved by the SIA; the IOS, a measure of relative success derived from the TIA; and the FI, calculated from the flattening effect achieved by the correction of the SIA. When examined together, the three provide a comprehensive understanding of any astigmatic change and what proportion of the astigmatism treatment has been effectively applied.

Using this method, favorable changes at the preoperative astigmatism meridian are quantified by flattening effect and ineffective changes are evaluated by torque. The necessary information also is available to the surgeon as how efficient it is in his or her laser correcting astigmatism (shown by the CI) and how do the astigmatic results of his or her laser compare to other lasers and other techniques (shown by the IOS). I believe this method provides a comprehensive understanding of induced astigmatic change and offers significant advantages by enabling an integrated examination of all changes applicable to keratometry, topography or refraction values.

For Your Information:


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—Noel A. Alpins, FRACO, FRACO (Ophth), FACS