Noel A. Alpins, F.R.A.C.O., F.C.Ophth., F.A.C.S., replies:

I thank Drs. Schiller and Guthrie for their interest and comments on the method of astigmatism analysis I have described. I am pleased to respond to their detailed comments.

The value for the magnitude of error in Figure 7 is correct, as it is derived by subtracting the target induced astigmatism (TIA) from the surgically induced astigmatism (SIA) after each has been rounded to two decimal places.

I thank Drs. Schiller and Guthrie for identifying the omission in the original manuscript of equal signs ("=") from two equations. The angle of the difference vector is correctly stated on page 527 in the left column and identified as $\theta 32 = \theta 32d/2$, but unfortunately, when restated in the right column, the "d" was omitted. It should read:

$$\theta diff = \theta 32d/2$$

I regret any confusion caused by these omissions. I presume Drs. Schiller and Guthrie meant to say that they consistently obtained values half (not twice) the ones listed in the article; their detailed calculations suggest this to be the case. After performing conventional vector analysis, using a double angle vector diagram employing rectangular coordinates, one would not expect to halve the angle calculated more than one time, nor to treat the difference vector angle differently from other vector angles.

The defined astigmatism values (p 525) conventionally refer to the steepest axis, whether they be for keratometry, topography, or refraction. Drs. Schiller and Guthrie correctly identify refraction as represented by the plus cylinder axis; however, it would be misleading to believe that working in a particular cylinder notation is a requirement to understand or work with the method. Nonetheless, even those of us past the novice stage sometimes find it perplexing to resolve "plus" and "minus" cylinder notation relative to corneal astigmatism and prefer to work in a selected mode. I find it is easier to work in minus cylinder notation, as the amount of myopia is more easily identified and the axis of the minus cylinder notation coincides with the axis of the TIA when refraction is the sole determinant of treatment in astigmatism surgery.

The magnitude of the SIA vector, TIA vector, or difference vector can only be positive; it is always the absolute value of the vector calculation obtained. To understand this principle, one might consider an airplane pilot determining the distance of the plane from the point of commencement of flight. All positions on the map indicate a positive distance from this point. While the distance could be zero (that is, the plane is at the starting point), a negative distance is not possible at any map position. A negative sign preceding the vector indicates that its axis must be reversed 180 degrees to obtain its true orientation in terms of its steepening force. The required adjustment is detailed in theory and methods (pp 526 and 527).

Drs. Schiller and Guthrie correctly recognize the need for an axis for zero targeted astigmatism but are inconsistent when claiming exactitudes to be absurd. Mathematical precision, in fact, leads to clearer understanding of a subject. A major impediment to our understanding of astigmatic changes in the past has been the absence of precise goals. The necessity for precision in defining our goals and calculating errors—in this case the difference vector's magnitude and axis—is stated in the first sentence of the article's abstract. When a vector's magnitude is zero, it is consistent with, but not essential to, the method to identify its orientation. Those who prefer to disregard it can do so.

Careful consideration was given in selecting all nomenclature, and the terms chosen were considered the most appropriate. Familiarity with terms comes with their usage, and use of the abbreviation "TIA" for the targeted induced astigmatism would assist in resolving any apparent ambiguity.

Suggested "medico-legal ramifications" should not interfere with our desire to minimize surgical errors by identifying and measuring them. My method recognizes that astigmatism will remain after treatment when preoperative measurements of topography and refraction do not coincide and explains the failure to achieve the goal of zero astigmatism at both planes. The medico-legal concerns of Drs. Schiller and Guthrie may be allayed with this information and also with the knowledge that, prior to surgery, the surgeon can calculate the residual astigmatism that will inevitably remain. It is only by performing such analysis that he or she can seek to achieve the optimal resolution of this prevailing conflict in astigmatism surgery.