IOL), and they reduced the overall astigmatism of the eyes by correcting for astigmatism at the cornea. The accuracy of estimating corneal plane cylinder power is explored in the articles, and an alternative calculation method to the one used in the Alcon online toric calculator is proposed. Unfortunately, the "vertex power" formula that is given is not appropriate for converting from the IOL toric power to the corneal toric power (it was also originally mistyped, and the correct equation is $E = F / [1 + (d/1.336)F]$). The basis for this equation is a calculation that can be used to estimate the refractive error at the spectacle plane if the refractive error of an eye is known at the corneal plane. The calculation assumes that collimated light is initially incident on the cornea when the refraction is determined and that collimated light is also incident at the spectacle plane when the alternative refraction is calculated. This equation does not correctly describe the imaging situation in the eye, where collimated light that is focused with high vergence by the cornea is no longer collimated at the IOL.

The correct calculation method is given instead by IOL power calculation formulas,[3] where a power change at the cornea can be related to a power change at the IOL using a "thin lens" calculation. The Alcon online toric calculator gives values similar to these standard calculation methods, although the various formulas make different adjustments to some of the primary parameters and the results from different formulas are not identical. The formulas also estimate an anterior chamber depth (ACD) value, which is the distance from the cornea to the IOL in a thin lens model of the eye, but this is not directly equivalent to a physical distance. Goggin and colleagues use a similar parameter for the vertex power equation but appear to have used physical postoperative ACDs in the calculations, with values measured using IOLMaster, which is not approved for this purpose.[4] Errors in these values may also be affecting the analysis.

Overall, the 2 articles by Goggin and colleagues discuss many of the issues surrounding calculations for toric IOLs, which are often related to the issues surrounding IOL power calculation in general. Unfortunately, the use of the vertex power formula in these articles is incorrect, and the conclusion by the authors that there is a significant error in the Alcon online toric calculator is also incorrect. The clinical results are a consequence instead of the many variables that can affect IOL power calculation and astigmatic outcomes, and I look forward to additional research on this topic.

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Exact Toric Intraocular Lens Calculations Using Currently Available Lens Constants

The article by Goggin et al[1] does an excellent job explaining that the ratio of the IOL plane cylinder needed to neutralize the corneal plane cylinder in toric IOLs cannot be a constant but must vary according to the effective lens position (ELP) and meridional powers of the toric IOL. Failure to compensate for these variables when selecting a toric IOL is a significant source of error, especially in unusual eyes. However, there are 2 differences in their calculations from those using standard IOL formulas (Holladay 1, SRK/T, Haigis, Hoffer Q, and Holladay 2) that make the results unique to their methods and do not apply to other IOL formulas.[2]

The first difference is related to the ELP. The authors used the distance from the posterior corneal vertex to the anterior vertex of the IOL (internal ACD + central corneal thickness). The calculation for converting the measured distance to the anterior vertex of the IOL to the equivalent thin lens plane was reported in 1998.[3] All currently available lens constants (A-constant, ELP, Surgeon Factor) assume an infinitely thin IOL. For the equiconvex Alcon SN60T3-9 IOL used in the study, the equivalent thin lens plane is actually posterior to the back vertex of the IOL by approximately 0.60 mm. With a nominal thickness of approximately 0.65 mm for a 20-D power, the additional distance beyond the anterior vertex of the IOL would be 1.25 mm (0.60 + 0.65) more than the value used by the authors. An average value of 3.92 mm for the postoperative ELP found by the authors vs the manufacturer's average ELP of 5.20 mm (difference of 1.28 mm) agrees very closely with the 1.25-mm thin lens calculation. Using the shorter distance results in much lower IOL power and toricity than would be obtained using the higher value.

The second difference relates to the index of refraction of 1.336, cited by the authors for aqueous and corneal tissue using Duke-Elder and Abrams[4] as a reference. The index of refraction for corneal tissue is 1.376. The 1.336 used by the authors as the net index of refraction is far too high. Commonly used values range from 1.3215 to 1.3333 and, as reported in 2009, a value of 1.3283 is optimal.[5] Using the higher value for the net index results in a higher corneal power that in turn results in lower IOL power and toricity than would normally be obtained with standard IOL calculations.

As can be seen in Table 1 in their article,[1] the constant ratio used by Alcon is 1.46 (obtained by dividing the IOL plane cylinder by the corneal plane cylinder). The authors would have found their average ratio to be 1.14 ($1.46 \times 1.58/2.02$ = manufacturer's ratio × manufacturer's predicted mean cylinder/authors' predicted mean cylinder). This lower value of 1.14 will work in the authors' formula but will not work in the current standard IOL formulas mentioned here. This is why the authors could not use their formula for the actual spheroequivalent IOL calculation, as it would yield much lower powers than standard IOL calculations, resulting in significant hyperopic surprises.

We recently published an article with a table that gives the ratios for IOL cylinder to corneal cylinder for various ELPs and spheroequivalent powers of an IOL.[6] For an IOL with a spheroequivalent power of 34 D and an ELP of 4.0 mm, a low ratio of 1.20 is obtained (very near the authors' ratio of 1.14 with an ELP of 3.92 mm). For a spheroequivalent power of 10 D and an ELP of 6.5 mm, a high ratio of 1.75 is obtained. For a 22-D IOL and an ELP of 5.50 mm, a ratio of 1.45 is obtained, which is very close to the manufacturer's ratio of 1.46. The company could not have been as far from the mean constant value as suggested (1.14 vs 1.46, respectively) or they would not have been able to receive approval by the US Food and Drug Administration. However, it must be emphasized that the more unusual the actual patient values are, the larger the error made by using a constant ratio is.

The only exact commercial calculators available at this time are the Abbott Medical Optics Express Calculator and the Holladay IOL Consultant Program[7] for which I wrote the algorithms a few years ago. It is also possible to solve for the toricity and exact axis of the IOL from the postoperative refraction and postoperative keratometry so that one can determine the exact amount of rotation necessary to minimize the residual astigmatism if the IOL is misaligned. This solution is somewhat more complicated because it involves another intermediate cross-cylinder calculation when the IOL axis is not aligned with the steepest meridian of the cornea. I thank the authors for making this extremely important clinical observation and hope that these comments explaining the difference between their results and those using standard IOL formulas are helpful. It does not minimize the importance of their valuable contribution.

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Toric Intraocular Lens Calculations

Goggin et al[1] should be commended for their interesting analysis of the conversion from the IOL to the corneal plane of the cylinder of toric lenses, as to our knowledge no one else has focused the attention on such a relevant topic. However, some important issues must be addressed.

When using the example of the SN60T3 IOL in the introduction, the authors confused "thin lens" and "thick lens" formulas. They calculated the equivalent cylinder at the corneal plane "using the manufacturer's effective lens position of 5.2 mm." By means of the thick lens vertex power formula, they obtained values of 1.32 D and 1.22 D, respectively, for the 17.0-D and 28.0-D IOLs, compared with the nominal 1.03-D value provided by the manufacturer. These calculations are not correct because the 5.2-mm ELP given by the manufacturer (and adopted by the authors) is valid only for thin lens formulas. In fact, it describes the principal plane of the thin lens and does not correspond to the physical distance of any thick lens, which is usually posterior to the actual position of the anterior surface of the IOL in the capsular bag.[2,3] As a consequence, the ELP cannot be entered into any thick lens formula, like the authors have done.

When defining the distance between the corneal endothelium and the anterior IOL surface, the term *aqueous depth* should be used instead of *anterior chamber depth*.[4] It is not clear what method was used by the authors when measuring such a distance postoperatively.

The authors calculated *d* in the vertex power formula as the distance between the corneal vertex and the anterior IOL surface. Actually, the toric Acrysof features its cylindrical power on the posterior surface[5] so that it would be appropriate to include the IOL thickness into *d*. Accordingly, the mean (SD) *d* (3.92 [0.86] mm) used by the authors seems too low as it does not include the IOL thickness. Although this parameter is not provided by the manufacturer, it has been reported to be 0.615 mm (range, 0.450-0.750 mm) for the Acrysof MA60AC, which has the same optic configuration as the investigated IOL.[6]

Surprisingly, the mean (SD) postoperative aqueous depth of this study (3.92 [0.86] mm) is considerably lower than the same value found by our group with immersion ultrasonographic biometry (4.72 [0.37] mm) and a Scheimpflug camera (4.76 [0.39] mm) for the Acrysof SA60AT, which has the same optic configuration as the Acrysof SN60T.[7] Similarly, Olsen[8] used immersion biometry and reported a mean (SD) of 4.48 (0.30) mm for the Acrysof MA60AC. This difference may be related either to a different method of aqueous depth measurement or to a different sample. An explanation should be forthcoming. Overall, the total distance between the corneal vertex and the posterior IOL toric surface in an average case should be, according to our data, 4.76 + 0.615 mm, ie, 5.375 mm, a value much higher than the *d* used by the authors (mean [SD], 3.92 [0.86] mm).

It is not appropriate to use a single value (1.336) for the refractive index of aqueous and cornea, as the refractive index of the former is 1.336 and that of the latter is