letters to the editor

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INTRAOCULAR LENS POWER CALCULATION

To the Editor:

I read with great interest the article about intraocular lens (IOL) calculation by Jack Holladay and coworkers.[1] The theoretical approach coupled with empirical corrections seems promising and needs further study.

It was disappointing, however, to learn that the "Holladay" approach introduces a new and poorly defined factor called the "surgeon factor." The authors claim that this factor is a measure of the distance between the iris plane and the IOL, but since it is calculated from the postoperative refraction, it includes an off-set error between the clinical measurements and the theoretical predictions. The authors failed in this respect to distinguish between the prediction of the IOL position and other empirical corrections.

The idea of using the (calculated) iris plane as a reference point for the IOL position has been studied.[2,3] In my opinion, it is better to show the actual accuracy of a method for predicting the IOL position, which may be used by others, than to introduce new mysterious factors of uncertain nature. However, even if the postoperative IOL chamber depth can be predicted by a given method, a residual error between the observed refractions and the predictions may remain. This error might as well be called an "axial length" correction because the axial length measurement is probably the most vulnerable step, but any error in calibration (or formula) has this effect and may call for an empirical correction. The important point is that it can be sorted out as a "residual factor" different from the question about the IOL position.

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1. Holladay JT, Prager TC, Chandler TY, Musgrove KH, et al: A three-part system for refining intraocular lens power calculations. *J Cataract Refract Surg* 14:17-24, 1988
2. Fyodorov SN, Galin MA, Linksz A: Calculation of the optical power of intraocular lenses. *Invest Ophthalmol* 14:625-628, 1975
3. Olsen T: Prediction of intraocular lens position after cataract extraction. *J Cataract Refract Surg* 12:376-379, 1986

Jack T. Holladay, M.D., replies:

We are pleased that Dr. Olsen found our article interesting, but we would like to clarify further our "surgeon factor."

The term surgeon factor, aside from the iris to implanted lens depth, also reflects the many variable factors that must be taken into account by each surgeon to optimize his results. Dr. Olsen's argument that it may not correlate exactly with the measured distance because of multiple offset errors is true, as we mentioned in the article.

As shown in Table 6 of our article, we identified nine factors that can lead to differences among surgeons, each of which can result in an offset bias that could be evaluated independently by multivariant analysis. Specifically, an empirical correction for the A-scan unit, keratometer, consistent corneal changes following surgery, lens labeling, etc., can all have specific offset biases.

Our investigations have shown that the present variability in these factors make independent offset biases for each parameter unnecessary and make no improvement on choosing a single bias, the surgeon factor. In addition, the formula also compensates for the improper choice of constants, such as the retinal thickness and index of refraction of the cornea. We did not fail to distinguish between these factors and the intraocular lens (IOL) position, but merely explained and demonstrated that a single value could improve intraocular power predictions.

We were certainly aware of Dr. Fyodorov's calculations predicting the anterior chamber depth (ACD), and cited his article as the second reference in our article. We also stated that his calculation did not take into account the asphericity of the cornea or the steeper posterior corneal radius compared to the anterior radius. Our first three formulas take these factors into account.[1] These formulas use the average corneal thickness in the cataract age group added to the internal ACD (posterior corneal vertex to the anterior iris plane). Because of the peripheral corneal flattening, the anterior corneal radius is used rather than the steeper posterior radius.

Although we evaluated this calculation in over 50 aphakic patients, we were more interested in determining the effect on the theoretical vergence formula and its accuracy with respect to other formulas. Obviously, if our ACD calculation did not improve the overall IOL power prediction, the ability to calculate the postoperative ACD more accurately is inconsequential. In addition, the variables are not independent and their interactive effect could not be predicted without performing actual IOL calculations.

We therefore tested the entire combination of formulas against seven other formulas in 2,000 eyes. The superiority of our results support the use of our formulas for the best relative accuracy at this time. All the formulas and the reverse solution for the surgeon factor are given in the appendix of our article.

Dr. Olsen has made significant contributions in this area and we hope that he will independently evaluate our formulas relative to others he has tested to confirm our results as Dr. Sanders has done in his most recent article.[2]

REFERENCES

1. Holladay JT, Prager TC, Chandler TY, Musgrove KH, et al: A three-part system for refining intraocular lens power calculations. *J Cataract Refract Surg* 14:17-24, 1988
2. Sanders DR, Retzlaff J, Kraff MC: Comparison of the SRK II™ formula and other second generation formulas. *J Cataract Refract Surg* 14:136-141, 1988

To the Editor:

We congratulate Sanders, Retzlaff, and Kraff on their modification of the SRK formula (Comparison of the SRK II™ formula and other second generation formulas. *J Cataract Refract Surg* 14:136-141, 1988). We believe these modifications will improve their results in unusual eyes, but there are two points in their study we would like to address.

First, Sanders and coworkers claim that with the SRK II, in long or short eyes, the prediction results will be comparable to the Holladay formula. They support this statement by comparing the mean absolute error for 167 short eyes (< 22.00 mm) and 306 long eyes (> 24.50 mm). We agree with their method of analysis using mean absolute error but point out that the reason they were unable to show a difference was because of the large percentage of pooled data from multiple surgeons using the same lens style.

Of the 2,068 cases used in their analysis, 944 cases (46%) were from pooled data from multiple surgeons using the same lens style. This is not the same as one surgeon using one lens as was done with the other 54%. Pooling cases from multiple surgeons introduces a variability or "blur" in the data, which causes formulas that are actually different in performance to appear similar. Certainly these authors are aware of this variability introduced by pooling surgeons, since they were among the first to show the need for an individualized A-constant for each surgeon and lens in their original formula.

In our Tables 1, 2, and 3, we show the difference between the SRK II and the Holladay formulas for various K-readings, axial lengths, and target refractions. These three tables illustrate that there is a

Table 1. Difference in IOL powers predicted by Holladay and SRK II formulas* (average K reading = 40 D).

Desired Refraction	Axial Length (mm)				
	19.5	21.5	23.5	25.5	27.5
−8	+2.07	+1.14	+0.66	+0.63	+1.70
−4	+2.79	+1.75	+1.13	+0.94	+1.01
0	+2.99	+1.80	+1.01	+0.62	−0.31
+4	+2.56	+1.20	+0.18	−0.48	−2.40
+8	+1.38	−0.22	−1.53	−2.52	−5.44

*All values are in diopters and represent the power that must be added to the SRK II IOL powers to achieve the same result as the Holladay formula when an IOL with an A-constant of 118.5 is used (S factor = 1.51).

Table 2. Difference in IOL powers predicted by Holladay and SRK II formulas* (average K reading = 44 D).

Desired Refraction	Axial Length (mm)				
	19.5	21.5	23.5	25.5	27.5
−8	+1.80	+0.81	+0.27	+0.19	+0.89
−4	+2.34	+1.19	+0.44	+0.10	−0.21
0	+2.33	+0.98	−0.03	−0.71	−2.02
+4	+1.65	+0.05	−1.30	−2.40	−4.71
+8	+0.17	−1.76	−3.54	−5.20	−8.51

*All values are in diopters and represent the power that must be added to the SRK II IOL powers to achieve the same result as the Holladay formula when an IOL with an A-constant of 118.5 is used (S factor = 1.51).

Table 3. Difference in IOL powers predicted by Holladay and SRK II formulas* (average K reading = 48 D).

Desired Refraction	Axial Length (mm)				
	19.5	21.5	23.5	25.5	27.5
−8	+1.40	+0.33	−0.23	+1.86	−0.13
−4	+1.73	+0.43	−0.47	+0.09	−1.91
0	+1.46	−0.13	−1.45	−2.57	−4.57
+4	+0.49	−1.47	−3.34	−6.33	−8.33
+8	−1.36	−3.79	−6.35	−11.50	−13.49

*All values are in diopters and represent the power that must be added to the SRK II IOL powers to achieve the same result as the Holladay formula when an IOL with an A-constant of 118.5 is used (S factor = 1.51).

definite difference between the formulas, which we believe is clinically significant for an individual surgeon, especially in unusual eyes. The inability to show formula differences with 46% of the cases representing pooled data is not surprising, since differences in A-scan units, keratometers, and surgical techniques introduce a significant variability.[1]

Our second criticism relates to the method by which intraocular lens (IOL) powers are calculated when the target refraction is also unusual; i.e., the desired postoperative refraction is greater than 2 diopters (D) of myopia or hyperopia. These situations are admittedly rare but do occur with monocular cataracts, asymmetric cataracts in which the postoperative refraction for the operative eye must be near the refraction of the unoperative eye, or with a patient who has been able to read without glasses his whole life and wants to remain moderately myopic (from −2 D to −4 D). It is in these situations that the SRK II and the Holladay formulas show the greatest difference.

Sanders and coworkers have recommended taking the desired refraction, multiplying it by a constant, and adding this value to the emmetropic IOL power to obtain the proper implant power. The constant has been reduced from 1.5, as suggested in their original work, to 1.00 for emmetropic powers less than 14 D and to 1.25 for emmetropic powers greater than 14 D.

Our studies show that this "constant" varies from 1.00 to 2.00 and that the relationship is nonlinear and depends on axial length, corneal power, IOL power, and the position of the lens within the eye. It is true that there would be a weak correlation with lens power alone, since low power lenses are more likely to be implanted in long eyes with flat corneas and higher power lenses in short eyes with steep corneas. Although this method may appear helpful in large data sets, it is often wrong for an individual case.

For example, the recommended value of the "constant" should be dramatically different (1.14 vs. 1.40) when attempting to achieve a −4 D refraction in a normal patient (axial length = 23.5, Ks = 44 D) for a posterior chamber versus an anterior chamber lens, even though the lens powers recommended are both over 14 D. The inaccuracies and inconsistencies in these situations are further supported by Dr. Thomas Cravy's work presented in April at the annual ASCRS meeting. Dr. Cravy found that in some cases conversion constants ranging from much less than 1.00 to greater than 2.00 were necessary to improve his refraction prediction accuracy using the SRK formula.

In summary, we agree that in average eyes for desired refractions near emmetropia the SRK II and the Holladay formulas are not significantly different clinically. Tables 1, 2, and 3, however, demonstrate a difference between the two formulas in unusual eyes, but if enough pooled data (multiple surgeons using the same lens style grouped together) are used, the differences will be obscured by the variability introduced. Finally, when a desired postoperative refraction of greater than 2 D of myopia or hyperopia is desired, using a "constant" multiplier times the refraction added to the emmetropic lens power can result in significant errors.

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1. Holladay JT, Prager TC, Chandler TY, Musgrove KH, et al: A three-part system for refining intraocular lens power calculations. *J Cataract Refract Surg* 14:17-24, 1988.

Donald R. Sanders, M.D., Ph.D., John A. Retzlaff, M.D., and Manus C. Kraff, M.D., reply:

What is most interesting about the editorial criticisms of Drs. Holladay, Christie, and Prager is that, although there is a great deal of discussion about