Pursuing perfection in intraocular lens calculations: III. Criteria for analyzing outcomes

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n our first 2 guest editorials in the series “Pursuing perfection in intraocular lens calculations,” we suggested a methodologic classification of intraocular lens (IOL) calculation formulas, addressed limitations of current formulas and technologies, and discussed a number of measurement issues that can contribute to IOL calculation errors in outcomes and in reporting. In this editorial, we focus on criteria for analyzing outcomes.

As with all outcomes analyses, the goal must be to present outcomes in a way that accurately and concisely provides data that clinicians need for their practices and that researchers need to make new advances. In studies evaluating the accuracy of IOL power prediction using different IOL formulas or different ocular biometers, fundamentally we are interested in the difference between the predicted outcome preoperatively and the actual outcome achieved postoperatively. Various parameters have been analyzed and reported, and we recommend using the following parameters for all IOL calculation studies (Figure 1), recognizing that additional parameters might be included to describe unique features of the outcome:

1. Refractive prediction error. The refractive prediction error is calculated as the difference between the measured and predicted postoperative refractive spherical equivalent (actual refraction – predicted refraction). A negative refractive prediction error value indicates a more myopic result achieved than the predicted refraction, and a positive refractive prediction error represents a more hyperopic result. Key parameters for refractive prediction error are as follows:
   - Arithmetic mean error. Arithmetic mean error indicates a systematic prediction error. It may be statistically compared to zero, and an arithmetic mean error significantly different from zero indicates that systematic myopic or hyperopic outcomes are achieved.
   - Standard deviation (SD) and range. In a large sample of cases, the refractive prediction error values tend to be normally distributed and the SD and range of the refractive prediction error represent the amount of variation or dispersion of the refractive prediction error. A low SD indicates that the data points tend to be close to the arithmetic mean error. Because the SD is related to the square value of the difference of each value from the mean, it is affected by outliers. However, we are interested in outliers too, which are outcomes we want to avoid in IOL power calculations.

2. Lens constant optimization.
   - Lens constant optimization is performed to reduce the arithmetic mean error to zero, thereby eliminating the systematic myopic or hyperopic prediction error. As we discussed in our previous editorial, this is essential for the clinician, whether it is done on an individual basis or as derived externally from a large dataset.
   - Lens constant optimization is also mandatory for clinical studies. There are 2 ways to eliminate the systematic error: (1) optimize the lens constant for each formula in the study group and reanalyze the outcomes or (2) zero out the arithmetic mean error by adjusting the refractive prediction error for each eye up or down by an amount equal to the arithmetic mean error in that group. This elimination of systematic error is required before evaluating many of the parameters described below.

3. Mean absolute error (MAE) and median absolute error (MedAE). These values are calculated with data derived after reducing the arithmetic mean error to zero. The MAE is the average of the absolute differences between actual and predicted refractive outcomes and has been traditionally used as a primary outcome parameter in IOL calculation studies. Because absolute errors do not have a normal Gaussian distribution and an MAE is influenced by outliers, the MedAE has been proposed to replace the MAE. The MedAE represents the central location of the absolute errors and is less affected by outliers in a dataset. However, outliers should not be
ignored because these large deviations from the expected refractive outcome represent the worst outcomes that can occur after cataract surgery and are a common reason for litigation. Kane et al. nicely showed the information that both the MAE and the MedAE might provide; see Figure 2, which is modified from their article. In addition, the vast majority of articles on IOL calculation accuracy have reported only the MAE. Therefore, to obtain a complete picture of the dataset and facilitate comparison with previous studies, we recommend reporting both the MAE and the MedAE.

4. Percentage of Eyes Within Certain Range of Prediction Error. Traditionally, we report the percentage of eyes within ±0.50 diopter (D), ±1.00 D, and ±2.00 D of refractive prediction errors. However, with recent advances, better refractive outcomes are achieved, and we agree with the recent trends to also report percentages of eyes within ±0.25 D. If the study sample is sufficiently large, the data can be elegantly displayed in a histogram as recommended by Reinstein et al.7

5. Role of intraocular lens prediction error. By targeting the actual refraction following cataract surgery, the predicted IOL power for each method can be calculated. Then, the IOL prediction error is obtained by subtracting the predicted IOL power from the power of the IOL implanted (implanted IOL power – predicted IOL power). Thus, a positive value indicates that method predicts an IOL of lower power than the power of the implanted IOL; this would leave the patient hyperopic. For some types of datasets, the IOL prediction error is a useful parameter. For example, the ASCRS postrefractive surgery IOL calculator6 provides output of IOL powers in fractions of diopters. For these data, it is more straightforward to calculate the change in IOL power that would be required to achieve the actual postoperative refractive outcome, and this approach has been used previously. A limitation of using the IOL prediction error is that, if the authors wish to convert the IOL prediction error to refractive prediction error, the refractive prediction error is traditionally calculated with the assumption that 1.0 D of IOL prediction error produces 0.7 D of refractive prediction error at the spectacle plane. This ratio of 0.7 is an estimate and works best for IOL powers and ocular biometric parameters in the normal range.

6. Use of 1 or both eyes of a subject. Correlation often exists between measurements obtained from the right eye and left eye of a subject. If the correlation is not adjusted, an important problem in testing hypotheses is the possibility of making a type 1 error; that is, rejecting the null hypothesis (H0) when it is true. Statistical guidelines for analysis of data obtained from 1 or both eyes have been proposed.9–12 During study design, a decision should be made whether it is advantageous to collect data from both eyes. Inclusion of 1 eye simplifies analysis; however, it is prone to selection bias and wastes data. In situations in which either eye could be selected, the statistically valid procedure is to select the eye to be included in the study at random, unless an alternative can be justified. The selection criteria applied if 1 eye is chosen should be described clearly in the paper. If both eyes are included, adjusted analyses should be used. Advanced statistical models to address correlated data from paired eyes have been covered in the literature.9–12

7. Sample-size calculation. Statistical significance is dependent on sample size. A small difference can be statistically significant with a large sample, while a relatively large difference is often not statistically significant with a small sample.13 Therefore, as part of the process of designing the study, a sample-size calculation is required to determine the minimum number of patients to be included in the study. It will depend on the magnitude of outcome differences that are both likely to be found and are clinically meaningful. Sample-size calculation requires the collaboration of experienced biostatisticians and physician–researchers.

8. Recommended statistical methods for analyzing these data. To evaluate whether the mean refractive prediction error or IOL prediction error is significantly different from zero, we have to check whether the data are normally
the accuracy of IOL power calculation have a within-subject or repeated-measures design. That is, outcomes from more than 1 formula or device are evaluated for each eye. Figure 3 shows the statistical tests that we recommend for this type of study. In the unusual instance in which an IOL calculation study uses a between-subjects design, different statistical tests (not shown here) should be used. When multiple comparisons are performed between groups or formulas, the statistical analysis must be modified to reduce the risk for a type 1 error or false-positive result. A common method is the Bonferroni correction, although other approaches might be more appropriate depending on the study design.

With sound study design and appropriate data analysis and presentation, maximum information can be obtained from studies of the accuracy of IOL power prediction using different IOL formulas or different ocular biometers. Consistency and completeness in reporting aid both clinicians and researchers.

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REFERENCES
11. Armstrong RA. Statistical guidelines for the analysis of data obtained from one or both eyes. Ophthalmic Physiol Opt 2013; 33:7–14. Available at:

Figure 3. Flowchart for selection of a suitable statistical test. Top: Assess whether the refractive/IOL prediction error is significantly different from zero. Middle: Compare whether there is/are significant difference(s) in absolute prediction errors between IOL calculation formulas. Bottom: Evaluate whether the percentages of eyes within certain prediction errors are significantly different between formulas.


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