

Hirschberg Ratio Variability and Its Correction

Congratulations to Drs. Hasebe, Ohtsuki, Kono, and Nakahira on their fine contribution to strabology and strabometry published in the December issue (*Biometric Confirmation of the Hirschberg Ratio in Strabismic Children. Invest Ophthalmol Vis Sci.* 1998;39:2782-2785). We would like to make a few comments confirming and supplementing their findings.

1. A semantic note: we suggest to the authors (and recommend strongly for our contributors to *Binocular Vision & Strabismus*) the use of the term "corneal light reflection test" instead of "corneal light reflex test" to describe the Hirschberg and similar tests. We do this to avoid possible confusion with the neurologic reflex phenomenon, which is not a light reflection but a true neurologic reflex arc to light stimulation. Yes, "reflex" is not wrong, but the term we use, "reflection," avoids any possible confusion.

2. We were pleased to note the authors confirmed biometrically our previously reported finding¹ of the marked variability of the HR (Hirschberg ratio) from person to person. We note in their Figure 2, the markedly dispersed distribution of HR ratios, seemingly totally random, from 16 Δ /mm to 24 Δ /mm. It is important to note that although the average HR is close to 20 Δ /mm, many patients are still close to the traditional HR of 15 Δ /mm, whereas others have 50% greater HR. Equally important, there is no clinical information or finding on which the HR can be predicted for any given patient, including age and ocular dimensions. (See also 4 below.)

3. The authors did not biometrically determine HR over a range of binocular misalignments for each of their subjects, but we urge them to add to their characterization of the HR that it also is definitely not linear, according to our prior research.¹ Rather, the HR for any given patient tends to increase as the deviation increases, up to 80 Δ of esodeviation and 50 Δ of exodeviation, and then decreases again. The HR for our patients ranged from 20 Δ /mm for small deviation to 24 Δ /mm at the maximum and then back to 19 Δ /mm for esotropia of 95 Δ and 16 Δ /mm for 75 Δ XT. (See unnumbered second and third figure in our reference). This asymmetric nonlinearity is undoubtedly due to the combination of angle kappa and corneal asphericity.

4. There is, however, a way to eliminate all these HR problems for any single given patient. That is through photographic calibration of their own individual HR. By having pictures taken of the corneal light reflection test with the subject fixating at known gaze positions, much as we did in our experiment,¹ one can provide a calibration table for the HR for that given patient. That calibration can be used to determine quite accurately the strabismic angle of binocular misalignment for their deviation, not just in primary position, but in eccentric gaze positions as well.

5. When performing Hirschberg Corneal Light Reflection testing, we recommend that the Hirschberg measurement, whether performed by direct observation or by photography, be calculated (derived) in a manner parallel to the *iris plane*¹; i.e., as a fraction of corneal width (rather than the frontal

plane) as this produces a smaller error, from the real deviation, than does using the frontal plane. (This is more easily done on a photograph.)

6. Although the Hirschberg Corneal Light Reflection Test has long been considered a rough measurement, an estimate, a secondary, less than ideal measurement, a test to be used only when some type of prismatic measurement cannot be performed, we should remember that all these other prism measurement methods have their own set of measurement problems,² and all, except the *simultaneous* prism and cover test, do significantly disturb or interrupt whatever sort of binocular vision and binocular sensory and motor cooperation may be present and thereby or otherwise change the strabismic deviation angle.

The most important, "most real," measurement of a strabismic deviation still is in "free space," i.e., under conditions of normal binocular viewing, uncontaminated by the measurement method. This may or will ultimately be by a precise calibrated photogrammetric Hirschberg Corneal Light Reflection Test. It is the only such pure method. The work of these authors is another step toward that ideal strabometric method.

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The Authors Respond

We are most grateful to Dr. Paul E. Romano for his interesting comments on our work.

Our study used a biometrical approach to evaluate the Hirschberg Ratio (HR). The data support the validity of using the averaged HR for children of various ages despite structural growth of the eye. However, an observed intersubject variation of this ratio has the potential for large systematic measurement errors. It had been overlooked because of the poor precision of naked eye observations,¹ but is an obvious problem when higher precision photograph- or video-based techniques are used.

In the "Iris Plane Parallel Method," the strabismic angle is estimated on the basis of the proportion of displacement of the light reflection from the center of the pupil to the apparent, horizontal diameter of the cornea. Seemingly, this procedure has three advantages. First, the corneo-scleral limbus works well as a landmark under natural light condition.² Second, a scaling factor of the eye's image, i.e., an absolute value (in millimeters) of the displacement of the reflection is not re-

quired. Finally, a good linearity is empirically expected between that proportion and the strabismic angle.

The video-based Hirschberg test has been the routine examination in our clinic since we published the previous article.³ In this method, we can easily identify the entrance pupil through infrared video-image processing. Using the centroid of the pupil image as the landmark has an advantage because its coordinates can be calculated with subpixel resolution.^{3,4} The scaling factor is assured by the narrow depth of focus of its optics. The nonlinearity between the displacement of the light reflection and the strabismic angle is well calibrated, using the geometric model proposed by Brodie.⁵ Taking our biometrically confirmed HR, 19.9 PD/mm, we obtain a conversion equation, $D = 5.12 \sin(\theta)$, where D is the displacement of the light reflection from the center of the pupil (in millimeters), and θ is the strabismic angle (degrees), which includes the angle lambda (λ).

For rotations that are larger than 60 PD, mathematical calibration for the flattening of the peripheral cornea based on its individual topography is required.^{5,6} However, such a procedure might be complex enough to spoil the convenience of this test. Rather, at this moment, the video-based Hirschberg test should be confined to small-to-moderate angle deviations in the primary position of gaze, where the linearity of the measurement is assured and the result is less biased by the individual variation of the HR. The following are examples where we think this technique is preferred: (1) evaluation of surgical outcome, (2) confirmation of the prismatic correction

of strabismic deviation, which is equivalent to the Krimsky test, (3) assessment of binocular fixation pattern, and (4) detection of an associated phoria.

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