A comparison of cycloplegic refraction to the near retinoscopy technique for refractive error determination

MOHINDRA described a near retinoscopic technique as a substitute for cycloplegic procedures determining refractive error.\textsuperscript{1,2} This technique will be referred to herein as the "near retinoscopy technique." The basic technique requires occlusion of one eye while retinoscopy is performed on the open eye at a distance of 50 cm in a totally dark room. In this manner the subject will presumably fixate on the light of the retinoscope along the visual axis.\textsuperscript{3} An adjustment in lens power for both tonus of accommodation and working distance from the retinoscope light is estimated to be 1.25 dipters. This value was empirically derived from a study conducted on 27 adult subjects\textsuperscript{4} and again determined experimentally by measuring accommodative responses in adults.\textsuperscript{5} The 1.25 dipters is subtracted from the gross retinoscopy to yield the final noncycloplegic value.

Since its inception, the near retinoscopy technique has been promoted for use with infants and young children to provide a consistent refractive determination that compares favorably with cycloplegic techniques. Mohindra originally reported that the technique had good reliability with infants using a comparison between two examiners.\textsuperscript{1} There were several aspects of Mohindra’s study, however, that were not clear. First, the age range of the subjects was not given. This is important since variability in age may be a factor in determining the efficacy of the procedure. Second, although all subsequent studies of this technique used monocular occlusion, this one did not. However, it is possible that occlusion was used but not described in the procedure. Finally, although inspection of the published graphs appears to display good correlation between the two examiners, no statistical analysis was performed to verify this observation. The apparent variability of the hyperopic values may have reduced any statistical correlation to a much greater extent than can be deduced by a visual comparison of the graphs.

To confirm the accuracy of this technique as a reliable substitute for cycloplegic retinoscopy, Mohindra and Molinari compared the near retinoscopy method to cycloplegic refraction utilizing 31 subjects, 3–7 years of age.\textsuperscript{6} Their results provided good interexaminer reliability for spherical and cylindrical power (r=+0.83 and +0.75, respectively) and good correlation between techniques for spherical power (r=+0.75).

Unfortunately, the drugs used were 1% tropicamid (Mydriacyl) and 10% phenylephrine hydrochloride (Neo-Synephrine). Tropicamid is not an appropriate agent for cycloplegic refraction since it has been shown to leave an average 3.50D. of residual accommodation with as much as 6.25D. of accommodation in a sample ranging from infancy to 9 years of age.\textsuperscript{6,7} Although it has a rapid onset, with maximum cycloplegia occurring in 20–30 min, the effect quickly diminishes.\textsuperscript{8} Of course, phenylephrine hydrochloride has no cycloplegic action. One other problem with Mohindra and Moli-
nari’s study was that it did not include infants, the group that this refractive technique was designed to evaluate.

In a comparison study, Maino et al. evaluated a much larger (311 subjects) and younger sample (18–48 months). Their method of cycloplegia incorporated 0.75% tropicamide combined with 2.5% phenylephrine. The participants were first examined using the near retinoscopy technique of Mohindra and Molinari. Retinoscopy was performed 20 min after instillation of the drops. Results indicated that there was little agreement between the two procedures in preschool children. Using the 1.25 diopter correction factor, there was only a 35.7 percent agreement between the cycloplegic values and the adjusted near retinoscopy values. Other modifications of the correction factor were attempted with only a marginal improvement in agreement. When they evaluated children with larger refractive errors (≥+3.00 D.S. or ≥–1.00 cylinder), there was even less agreement. There was agreement only 27 percent of the time within +/-0.50 D.S. Although a large sample was used, infants were not evaluated and the drugs used for cycloplegia suffered from the same problems as the Mohindra and Molinari study.

Borghì and Rouse addressed the issue of using a better cycloplegic agent in their 1985 study. They compared the near retinoscopy method to cycloplegic retinoscopy utilizing an older sample of 21 subjects whose ages ranged from 3.5–10 years. One percent cyclopentolate was employed (2 drops in each eye repeated at 5 min intervals). Cycloplegic refraction was performed 35 to 40 min following the instillation of drops. On the average, 0.63D more plus power was measured by the cycloplegic method and these results were significantly different for the vertical, horizontal and combined meridians (p=0.005; 0.0005; and 0.0001 respectively). The authors indicated that if one were to “cut” the cycloplegic finding by +0.50D. to +1.00D. before prescribing, the results between the two procedures would be in close agreement.

There are a number of issues which remain to be resolved. First, the technique would have its greatest utility with infants, but this age group has not been studied directly. Although infants were evaluated for interexaminer reliability in Mohindra’s earliest study, infants were not evaluated for cycloplegic/near retinoscopy comparison in later studies. The Maino study included children in the 18–48 month age range while the Borghì and Rouse study included children 42–120 months.

Second, it is possible that covering one eye is not a necessary component of the procedure. The original paper did not use occlusion. Further, Griffin alludes to the possibility that occlusion does not make a difference. Finally, it is possible that the technique has greater merit with older children than with infants. The literature suggests that this may be the case. Variability may be less for the older population resulting in smaller differences between the near retinoscopy technique and cycloplegic retinoscopy. The present study was designed to investigate these possibilities.

Method

A total of 20 infants and young children from the pediatric population at the Chauncey Sparks Center for Developmental and Learning Disorders were used as subjects after obtaining the parents’ informed consent. The mean age for the overall group was 43.6 months (range: 3–109 months; SD=42.4 months). There were nine males and 11 females. For purposes of further analysis the participants were grouped into two age groups of 10 subjects: “infants” (range 3–12 months; mean=7 months, SD=3 months) and “children” (range 32–109 months; mean 80.2, SD=50.1 months).

The near retinoscopy technique was performed first for all participants. Each participant was randomly assigned to a counterbalanced order of binocular/monocular or monocular/binocular procedures. Near retinoscopy was rendered at a 50 cm test distance in a dark room by one examiner (KM). Lens bars were used to find the neutral point which indicated a change from “with” to “against.” The final recorded value was adjusted by subtracting the empirically derived value of 1.25 diopters used by Mohindra.

Following the near retinoscopy technique, cycloplegia was achieved with 1 drop of 1% cyclopentolate (Cyclogyl) in each eye followed by a waiting period of 45 min (+/-5 min). Retinoscopy followed in the same order as the near retinoscopy technique and was performed at 66 cm. The final recorded value was adjusted by subtracting 1.50 diopters, the working distance covered to dioptric value.

Results

Refractive comparison

Each eye of every subject in the two age groups was refracted a total of four times: Under monocular conditions with the near retinoscopy and cycloplegic techniques, and under binocular conditions with the near retinoscopy and cycloplegic techniques. Thus, on each age group, 80 refractive measurements were available for the right eye and for the left eye (10 subjects × 4 refractions/eye/subject) for both sphere and cylinder measures. When considering the two refractive techniques separately, a total of 40 refractive measurements were obtained for each technique.

Spherical values were analyzed in a mixed analysis of variance (ANOVA) using the P4V programs of BMDP. The variables included age group (infants and children), gender, technique (near retinoscopy and cy-
cycloplegic), ocular condition (monocular and binocular), eye (right and left), with repeated measures on the last three factors. There was a significant effect for technique, $F(1,16)=13.58$, $p<.002$, $MS_e=.195$, with means of $+0.53$ (SD=2.19) and $+1.97$ (SD=1.89) for the near retinoscopy and cycloplegic techniques, respectively. This result indicates that when the data from all participants are considered (infants and children combined), the near retinoscopy technique resulted in less refractive error than the cycloplegic technique. There was no significant difference between age groups, $F(1,16)=1.22$, $p>.28$, $MS_e=27.71$, with means of $+1.62$ (SD=2.53), and $+0.88$ (SD=1.64) for the infants and children, respectively.

As indicated by a nonsignificant interaction of technique and age group, $F(1,16)=2.93$, $p>.10$, $MS_e=.195$, the same pattern holds for both infants and children. The means were $+0.56$ (SD=2.67) and $+2.68$ (SD=1.89) for near retinoscopy and cycloplegic for the infants and $+0.50$ (SD=1.60) and $+1.26$ (SD=1.62) for the near retinoscopy and cycloplegic for the children.

The main effect for ocular condition was not statistically significant, $F(1,16)=.49$, $p>.49$, $MS_e=.09$, with means of $+1.23$ (SD=2.18) and $+1.27$ (SD=2.15) for monocular and binocular conditions, respectively. There were no interactions with ocular condition and age, $F(1,16)=.06$, $p>.81$, $MS_e=.09$, with means of $+1.59$ (SD=2.57) and $+1.64$ (SD=2.52) for the monocular and binocular conditions for the infants and $+0.87$ (SD=1.64) and $+0.89$ (SD=1.66) for the monocular and binocular conditions for the children. These results indicate that the effect of covering one eye during the objective refraction does not influence the measures for either age group.

One might speculate that there may be a difference if the data for the ocular conditions were treated separately for the near retinoscopy and cycloplegic techniques. However, the interaction of ocular condition and technique was not statistically significant, $F(1,16)=.14$, $p>.71$, $MS_e=.004$, with means for the monocular and binocular conditions of $>0.52$ (SD=2.22) and $+0.54$ (SD=2.18) with the near retinoscopy technique and $+1.94$ (SD=1.90) and $+1.99$ (SD=1.89) for the cycloplegic technique. This is an indication that there is no effect due to ocular condition for either the near retinoscopy or cycloplegic technique.

The main effect for gender was not significant, $F(1,16)=.25$, $p>.62$, $MS_e=27.71$, with means of $+1.31$ (SD=2.15) and $+1.20$ (SD=2.17) for the males and females, respectively. There was no interaction of gender and age, $F(1,16)=1.21$, $p>.28$, $MS_e=27.71$, with means for the males and females of $+2.60$ (SD=2.20) and $+1.19$ (SD=2.56), respectively, for the infants and $+0.67$ (SD=1.83) and $+1.20$ (SD=1.26), respectively, for the children. These results indicate that there was no statistically significant effect for gender for either age group.

There was no difference between the right and left eye as indicated by the nonsignificant main effect for eye, $F(1,16)=.48$, $p>.49$, $MS_e=2.61$, with means of $+1.38$ (SD=2.25) and $+1.12$ (SD=2.07) for the right and left eye, respectively. The interaction of eye and age was not significant, $F(1,16)=.88$, $p>.36$, $MS_e=2.61$. The means for the right and left eyes for the infants were $+1.16$ (SD=2.47) and $+1.63$ (SD=2.62), respectively, and for the children the corresponding means were $+1.14$ (SD=2.00) and $+0.61$ (SD=1.14). This nonsignificant main effect and interaction indicates that there were no differences between eyes for either age group. There were no other significant effects or higher order interactions with the spherical measures.

**Cylinder power comparison**

Cylinder power was used as the dependent variable in a second mixed ANOVA with the same variables as used in the analysis of the spherical refractive error data. As with spherical refractive error comparison, there was an overall significant difference between the two techniques for cylinder power $F(1,16)=10.25$, $p<.005$, $MS_e=1.25$. The mean cylinder value for the near retinoscopy method was $-0.20$ (SD=.36) while for the cycloplegic it was $-0.36$ (SD=.49). There was no mean effect for age $F(1,16)=0.04$, $p>.85$, $MS_e=1.25$, ocular condition (monocular and binocular), $F(1,16)=0.07$, $p>.79$, $MS_e=.02$, gender $F(1,16)=2.04$, $p>.17$, $MS_e=1.25$, and eye $F(1,16)=3.49$, $p>.08$, $MS_e=.15$. All interactions were nonsignificant.

**Discussion**

The results indicate that 1) there is a significant difference for both sphere and cylinder power between the cycloplegic and near retinoscopy technique; 2) it makes no difference whether the techniques are performed monocularly or binocularly as Griffin has suggested,11 3) there appears to be no significant difference as the result of gender, age or eye tested.

Borghi and Rouse's results suggest little difference (0.63 D more plus in the cycloplegic than the near retinoscopy method) between techniques for their sample although the differences were statistically significant. This may be explained by the age of the subjects whose ages ranged from 42-120 months. The average age of our total sample of 20 was 43.8 months (SD=42.4) with a maximum age of 109 months. Ten of those subjects were under 12 months or less with an average age of 7 months (SD=3), while the older children had an average age of 80.2 months (SD=30.1). Thus, any comparison between our study and that of Borghi and Rouse should be
confined to the older group. For these children, we found more plus in the cycloplegic refraction than observed with the near retinoscopy method (0.82D). This is very similar to Borghi and Rouse's value of 0.63D. However, for our infant group, the difference between the near retinoscopy and the cycloplegic technique was 2.12D, nearly three times greater than the older population, even though the interaction of age group and technique failed to reach conventional levels of statistical significance.

This suggests that using the near retinoscopy technique for anything but a gross indication of refractive error can lead to very tenuous conclusions concerning refractive error. With this in mind, we reanalyzed this data using all 20 subjects to see if the differences between techniques reveal greater differences for myopes or hyperopes. Difference calculations were made only on those subjects displaying either myopia on all measures (n=8) or hyperopia on all measures (n=12). The average difference between techniques for myopia was +2.61 (SD=1.79) while the difference for hyperopia was +0.65 (SD=0.78). This difference between myopia and hyperopia proved to be statistically significant \( F(1,16)=8.89, p<.009 \). However, due to the small sample size under the constraint mentioned above, we were unable to evaluate infants and children separately for these differences.

The final point to be made from this data concerns the interpretation of the correlation between the near retinoscopy values and those of cycloplegic refraction. Table 1 displays the correlation between the techniques for sphere and cylinder values under monocular and binocular conditions. The correlations between the techniques range from moderate (.63) to high (.90) and all are significantly greater than zero. Therefore, why can the two techniques not be utilized interchangeably? The reason is that correlation only indicates the degree of consistency between individuals, not the magnitude of the difference between measures. With strong positive correlations, this means that individuals who tend to display large values with cycloplegic agents also tend to display large values with the near retinoscopy technique. Conversely, those with low cycloplegic values will tend to be low with the near retinoscopy technique. Adding a correction constant such as +0.50 to +0.75D to the near retinoscopy value will not change an individual's ranking. After the correction factor, those with the greater values on one measure will still be relatively greater on the other measure while those low on one measure will also be low on the other. The average scores for the group will be more similar with such a correction, but the correlation between measures will not change. This means that the error in prediction will not change, only the group average. These problems are of even greater importance with the moderate correlations which have a higher error of prediction. It is the sphere measures that are utilized most, and for these there are only moderate correlations between the near retinoscopy and cycloplegic techniques. Figure 1 provides a scatterplot of combined measures comparing near retinoscopy with cycloplegia for spherical values under monocular and binocular conditions. A moderate correlation of 0.68 is obtained. The square of the correlation is .47 which means that the two methods have only 47 percent of their variance in common, leaving 53 percent unaccounted.

One other complication is that we know that if the near retinoscopy results increase in magnitude over an age range, then the cycloplegic results also will increase. However, the magnitude of the change depends on age and there is a trend for this difference to be greater for infants than for older children. Therefore, it is not appropriate to state that "on the average" the cycloplegic refraction will be +0.50D to +0.75D more plus.

| Table 1: Correlation coefficients: near retinoscopy versus cycloplegic refraction |
|---------------------|-----|-------------------|------|
| condition           | N   | correlation (R)   | P value |
| OD sphere           |     |                  |       |
| monocular           | 20  | .74               | <.001 |
| binocular           | 20  | .75               | <.001 |
| OS sphere           |     |                  |       |
| monocular           | 20  | .63               | <.002 |
| binocular           | 20  | .67               | <.001 |
| OD cylinder         |     |                  |       |
| monocular           | 20  | .90               | <.001 |
| binocular           | 20  | .86               | <.001 |
| OS cylinder         |     |                  |       |
| monocular           | 20  | .80               | <.001 |
| binocular           | 20  | .83               | <.001 |

![Figure 1: Spherical values for the left and right eye under monocular and binocular conditions were combined (COMBSM=near point retinoscopy; COMBS=cycloplegic retinoscopy). Their average values for each of the 20 subjects for the two refractive methods were then compared in this scatterplot. The correlation between methods was 0.68. The regression line was plotted with a slope of 0.52 and the Y intercept, -1.07D.](image)
than the near retinoscopy technique. Using the regression equations generated by these data will not be valid because there is a significant difference in values between techniques and there is a trend for the magnitude of this difference to be larger for infants than for younger children. It should be noted, however, that the interaction of age group and technique failed to reach conventional levels of statistical significance.

**Conclusion**

Contrary to other published reports, our data indicates that the near retinoscopy and cycloplegic techniques yield significantly different values and cannot be used interchangeably. There appears to be a trend towards less difference in older children but the size of our sample is too small to conclusively establish this trend. We suggest that until much larger studies of infants and young children are carefully conducted, the refractive results of the near retinoscopy technique should be interpreted with caution.

**References**


**Footnotes**

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