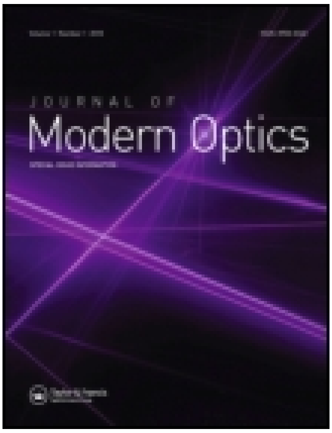

Journal of Modern Optics
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tmop20

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Published online: 04 Jun 2007.

To cite this article: Nisha S. Yeotikar , Ravi Chandra Bakaraju , P.S. Roopa Reddy & Kalyani Prasad (2007) Cycloplegic refraction and non-cycloplegic refraction using contralateral fogging: a comparative study, Journal of Modern Optics, 54:9, 1317-1324, DOI: 10.1080/09500340600855346

To link to this article: http://dx.doi.org/10.1080/09500340600855346

Journal of Modern Optics
Vol. 54, No. 9, 15 June 2007, 1317–1324

Cycloplegic refraction and non-cycloplegic refraction using contralateral fogging: a comparative study

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(*Received 29 September 2005; in final form 2 January 2006*)

The purpose of this study is to compare the retinoscopy values obtained from cycloplegic refraction and non-cycloplegic refraction done with contralateral fogging procedure on children. Performing retinoscopy on children is a challenge because of two significant problems encountered during the procedure, which include maintaining fixation and control of accommodation. Although cycloplegic refraction is a gold standard in order to relax the accommodation completely, it has its own limitations. Whereas when assessing refractive error using static retinoscopy, it is conventional to fog the contralateral eye with a high amount of plus lens, to prevent a blur-driven accommodative response from stimulating consensual accommodation in the examined eye. The study was performed on 31 healthy, non-strabismic subjects of 7 to 16 years of age. Initially the refractive status of the eye was assessed objectively by non-cycloplegic refraction, done by fogging the contralateral eye with +6.00 D, in a dimly illuminated room. Then 2 drops of cyclopentolate 1% were instilled separated by 5 min, in the tested eye. Retinoscopy was performed 25 to 30 min after the first drop was instilled. A statistically significant mean difference exists between the findings obtained ($p < 0.05$) in the spherical equivalent retinoscopy values (mean of 0.2944 D higher) with cycloplegic refraction when compared to non-cycloplegic refraction done with contralateral fogging. Non-cycloplegic refraction done with contralateral fogging technique as effective as the gold standard cycloplegic refraction technique for the measurement of refractive error in healthy, non-strabismic children.

1. Introduction

A broad range of methods and instrumentation has been developed to assess refractive error. However, irrespective of the procedure adopted, successful control of accommodative response is critical to obtain a valid estimation of the far point [1]. The most frequently used objective technique for determination of the distance refractive error is static retinoscopy. Retinoscopy is an objective method of estimating the refractive status of the eye, where a clinician locates the plane conjugate to the patient's retina with accommodation at a minimum (far-point plane), as the refractive error is defined only in the relaxed accommodative condition [2].

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Journal of Modern Optics
ISSN 0950–0340 print/ISSN 1362–3044 online © 2007 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/09500340600855346

The task of ensuring the relaxed accommodative state of the eye is achieved by several techniques. The simple technique of relaxing accommodation while performing retinoscopy is by asking the patient to fixate on a distant target such as a large Snellen letter or any non-accommodative target (neither of the eye is occluded). But the classic technique for control of accommodation, while objectively measuring the refractive status of the eye is cycloplegia. Cycloplegic agents paralyse the ciliary muscles arresting the accommodation completely. Relaxing the accommodation totally, while performing retinoscopy, is very difficult for patients with high amplitude of accommodation (or) active accommodation, i.e. mostly in the case of children. This problem is highly encountered in children because of their poor fixation ability, poor concentration with retinoscopic light being a major distracter, poor co-operation due to minimum interest, which may result in a wrong estimate of refractive status (over minus or under plus).

Fogging the contralateral eye inhibits blur-induced accommodation from stimulating a consensually driven increase in the accommodative response of the examined eye [3]. According to the accommodative pathway, since the afferent impulses from retina reach both sides of the Edinger Westphal nucleus, fogging the contralateral eye ensures *relaxed consensual accommodation*, i.e. accommodation in the tested eye [4, 5]. In this study, an effort is made to assess whether the non-cycloplegic refraction done with contralateral fogging canyield reasonably comparative results to that for cycloplegic refraction, on children.

Cycloplegia has its own limitations like peripheral aberrations of dilated pupil, blurred vision, restricted near work for patient, side effects of cycloplegic agents like restlessness, hallucinations, dryness of skin and mouth, tachycardia, etc., contra-indications like narrow anterior chamber angles, history of epilepsy, late recovery time, etc.

2. Methods

Thirty-one subjects (9 from KIMS, 5 from LVPEI and 17 from the Marica School), 11 girls and 20 boys, aged 7 to 16 years participated in the study after appropriate oral informed consent taken from both the parents and children in a language in which they were fluent. The study was performed at KIMS Hospital, LVPEI in the CECC Department and Bausch & Lomb School of Optometry.

2.1 *Inclusion criterion*

The inclusion criteria were between 7–16 years age group, hypermetropes up to +4.50 D and myopes up to −1.50 D.

2.2 *Exclusion criterion*

The exclusion criterion included any ocular pathology, any media opacities, which hampers vision, manifest strabismus, accommodative anomalies like accommodative insufficiency, accommodative infacility, accommodative spasm and amblyopia [6–9].

3. Clinical procedure

One examiner completed all the examination procedures in this study. The clinical procedures included a detailed ocularexamination which involved case history, visual acuity assessment with logMAR chart, dry static retinoscopy performed under a dimly illuminated room condition followed by subjective acceptance under fogging under a well-illuminated room condition. Later the extraocular motility was checked in all gazes and Hirschberg's test and cover test was performed to rule out any manifest strabismus. The patient was also examined for accommodative function to rule out any accommodative anomaly by measuring NPA12 and using accommodative flippers (±1.00 D). Then the clinical procedure proceeded with the slit lamp examination to rule out any ocular abnormality or pathology. All the subjects obtained corrected visual acuities of 20/20 (6/6) with either eye with no binocular abnormality or ocular disease. After this screening procedure, the dry static retinoscopy was performed with the contralateral eye being fogged with 6.00 D and the testing eye being fogged by the working distance lens (+1.50 D), under the dimly illuminated room condition. The retinoscope was placed 67 cm from the subject, in accordance with standard clinicalprotocol. The subject was instructed to view a 20/400 Snellen optotype located at a distance of 6 m. A similar procedure was performed for the other eye. Proper care was taken to make the subject fixate on the distant target and not on the retinoscopic light to ensure relaxed accommodation. The net refraction valuewas obtained by subtracting a correction factor of 1.50 D, i.e. working distance value, from the neutralizing lenses. Then a drop of topical anaesthetic was instilled in the examined eye (in a few cases, both eyes) followed by 2 drops of cyclopentolate 1% separated by 5 min. Retinoscopy was performed 25 to 30 min afterthe first drops were instilled, by asking the patient to look into the retinoscopic light to avoid off-axis error, which is more likely to occur because of peripheral aberrations through dilated pupil. While performing cycloplegic retinoscopy, care was taken to attend only the central 3–4 mm of pupil in order to avoid confusion of the movement of the retinoscopic reflex. Statistical data analysis was performed using the 'paired sample *t*-test' and the 'vector analysis' method [6]. Results are presented interms of spherical equivalent (M), two Jackson's cross cylinders (one at axis 0° with power J_0 and the other at axis 45° with power J_{45}) and blurring strength (P).

4. Results

All subjects obtained corrected visual acuity of at least 20/20 with the logMAR chart (either eye). Additionally, all the subjects had normal ocular health with no strabismus and normal accommodative function was confirmed.

Before the statistical tests were performed on the collected data, power vector analysis of the data was done for the description ofthe sphero-cylindrical value of the refraction from the view of a Fourier analysis of the power profile. The purpose of power vector analysis was to look at the problem of representing the sphero-cylindrical lenses from the point of view of Fourier analysis in order to gain additional insight into the numerical and statistical analysis of refractive data. The conventional practice of decomposing a sphero-cylinder into a combination of spherical lens and an ordinary cylindrical lens [10–12] leads to complications because the sphere and the cylinder components are not independent of each other. This lack of independence arises because a cylinder lens carries some spherical power called the 'mean spherical equivalent' [13]. Power profile is described by a simple Fourier series containing just three Fourier coefficients, which correspond to the natural parameters of an arbitrary sphero-cylindrical lens by a single point in a three-dimensional Dioptric space. The three Fourier coefficients are a spherical lens of power M and two Jackson's cross-cylinders, one at axis 0° with power J_0 and the other at axis 45° with power J_{45}.

The conversion of all the data into the rectangular Fourier was done with the help of a power vector electronic appendix available online at http://research.opt.indiana.edu/ [14].

Statistical analysis of the converted rectangular Fourier data was done with the help of SPSS 11.0 software and Analyse it! with Excel software. A paired *t*-test was performed.

A statistically significant ($p<0.05$) mean difference exists between the *Spherical Equivalent* (M), obtained in the retinoscopy values (mean of 0.298 D higher) of cycloplegic refraction when compared to non-cycloplegic refraction done with contralateral fogging (see figure 1). However the difference (0.298 D) is *NOT clinically significant*, *i.e. non-cycloplegic refraction done with contralateral fogging is as effectiveas the gold standard*, *cycloplegic refraction* (see table 1).

A statistically significant ($p<0.05$) mean difference exists between the *blurring strength* (**P**), obtained in the retinoscopy values (mean of 0.2158 D higher) of cycloplegic refraction when compared to non-cycloplegic refraction done with contralateral fogging (see figure 2). But the difference (0.2158 D) is *NOT clinically significant*.

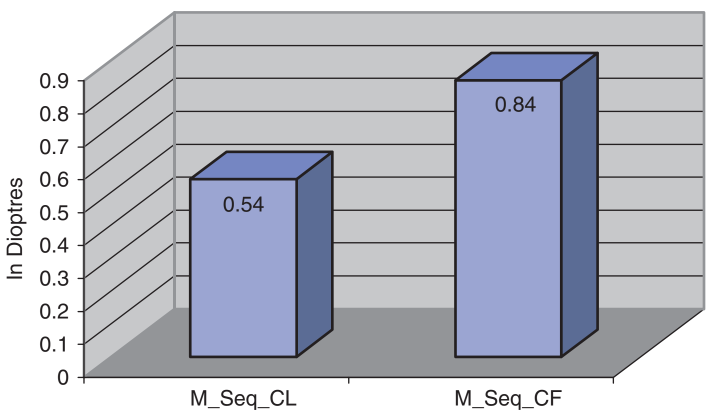

Figure 1. Contralateral versus cycloplegic spherical equivalent in all subjects. (The colour version of this figure is included in the online version of the journal.)

5. Validity of refraction (contralateral)

Validity of the refraction values (contralateral fogging) were statistically analysed by MEDCAL & 'Analyse it!' software using the Bland and Altman method of comparing continuous variables. Seven of my refraction values (contralateral fogging) were compared with those of a senior optometrist.

As the graphs indicate a good correlation between the values of my refraction and the senior optometrist's value, my refraction (contralateral fogging) is considered to be validated (see figures 3 and 4 and table 2).

6. Validation of refraction (cycloplegic)

Validity of the refraction values (cycloplegic) were statistically analysed by MEDCAL and 'Analyse it!' software using the Bland and Altman method of comparing continuous variables. 10 of my refraction values (cycloplegic) were compared with the Canon Auto refractor.

Table 1. Paired differences of the vectors M, J_0, J_{45} and P.

	Paired differences						
	Mean	SD	SE	95% CI of the differences	t-statistic	dF	2-tailed p
M	**−0.298**	0.482	0.07	−0.43 to −0.16	**−4.27**	47	**0.0001**
J_0	**0.0040**	0.15	0.02	−0.04 to 0.05	**0.181**	47	**0.857**
J_{45}	**−0.0017**	0.12	0.02	−0.04 to 0.03	**−0.98**	47	**0.922**
P	**−0.2158**	0.43	0.06	−0.34 to −0.09	**−3.461**	47	**0.001**

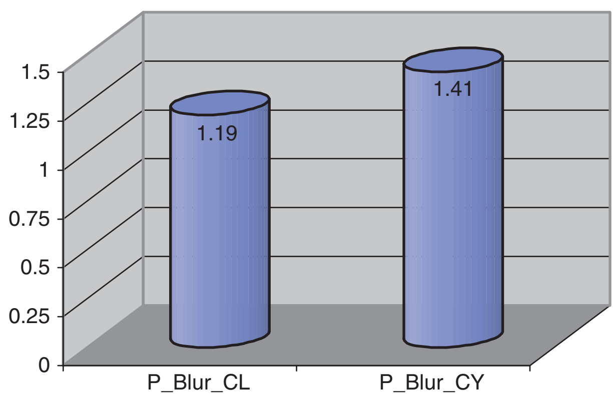

Figure 2. Contralateral versus cyclo blurring strength in all subjects. (The colour version of this figure is included in the online version of the journal.)

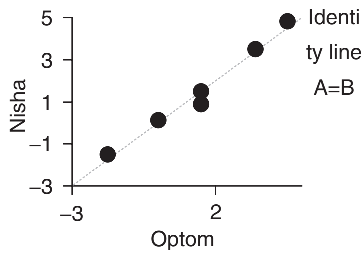

Figure 3. NSY vs. Optom Plot.

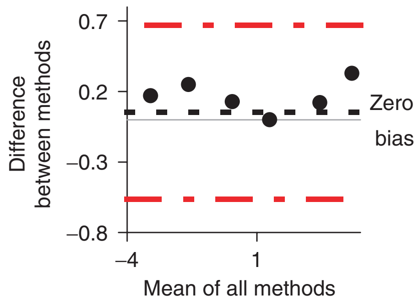

Figure 4. Bland and Altman's plot: difference between methods versus mean of all methods. (The colour version of this figure is included in the online version of the journal.)

Table 2. 95% CI levels for NSY vs. Optom.

Bias	0.054		
95% CI	−0.237	to 0.346	
95% limits of agreement		95% CI	
Lower	−0.563	−0.962	to −0.164
Upper	0.672	0.273	to 1.070

As the graphs indicate a good correlation between the values of my refraction and the Canon auto refractor value, my refraction (cycloplegic) is considered to be valid (see figures 5 and 6 and table 3).

7. Discussion

The results of this study indicate that contralateral fogging can yield equivalent results as those for cycloplegic refraction. In a previous study by Bannon [15], it was revealed that cycloplegia tends to result in yielding more hyperopia and less myopia, as compared to non-cycloplegic refraction in a younger age group. In our study, we found that even the non-cycloplegic refraction using contralateral fogging results in

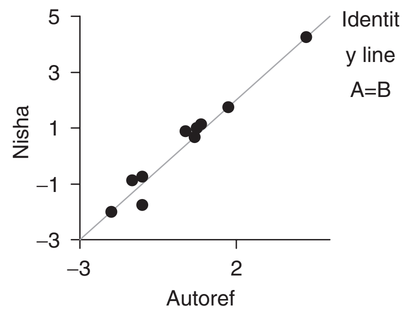

Figure 5. Nisha vs. Autoref.

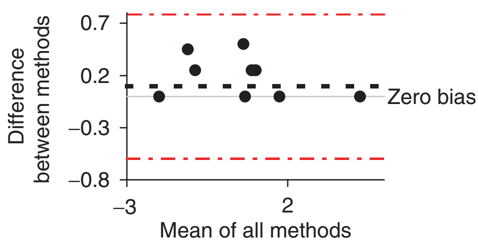

Figure 6. Bland and Altman's plot: difference between methods versus mean of all methods. (The colour version of this figure is included in the online version of the journal.)

Table 3. 95% CI for NSY vs. Autorefractor.

Bias	0.095		
95% CI	–0.156	to 0.346	
95% limits of agreement		95% CI	
Lower	–0.594	–0.966	to –0.222
Upper	0.784	0.412	to 1.156

more plus and less minus, when performed on children. Big *et al*. [16] attempted to assess the effect of fogging lens placed before the non-tested eye while performing static retinoscopy, and concluded that the introduction of thesupplementary lens produced a significant difference in retinoscopy findings in hyperopic individuals. He found that a mean increase in hyperopia of 0.33 D was observed when the +1.50 D lens was placed before the non-tested eye. Chiu *et al*. [17] studied the effect of contralateral fogging during refractive error assessment. No significant change in mean refractive state was observed for up to 5.00 D of contralateral fogging. But, 6.00 D of contralateral fogging produced asignificant mean increase. Hence from the above two studies we have considered +6.00 D as the ideal fogging lens and compared the two refraction values. Moreover, the accommodative pathway suggests that the contralateral fogging procedure prevents consensual accommodation, which gives a comparable effect of relaxed accommodative state obtained by that of cycloplegia.

As per the literature, most of the studies have been performed on children comparing the retinoscopy values of non-cycloplegic and cycloplegic refraction, assessing the effect of contralateral fogging for refractive error estimation; however, there is no study emphasizing non-cycloplegic refraction done with contralateral fogging compared with the gold standard, cycloplegic refraction.

8. Conclusion

The results suggest that non-cycloplegic refraction done with a contralateral fogging technique is as effective as the gold standard cycloplegic refraction technique for the measurement of refractive error in healthy, non-strabismic children. The mean-difference between refraction values obtained by non-cycloplegic refraction with contralateral fogging and cycloplegic refraction is clinically not significant, though it yielded to be statistically significant ($p < 0.05$).

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