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Comparison of endpoint of subjective cycloplegic refraction with artificial aperture and post-mydriatic test among adults with refractive error

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Abstract:

PURPOSE: There is a need to understand the requirement for the post-mydriatic test (PMT) among adults for the final prescription of spectacles as this test increases the cost of eye care and causes inconvenience to the patient because of the additional visit to an eye care practitioner. We aim to compare the cycloplegic subjective refraction using apertures of various sizes and PMT in an adult population.

METHODS: This prospective crossover study was conducted under standard settings in an eye clinic. Adult individuals between 18 and 35 years of with emmetropia and various degrees of ametropia participated in this study. Individuals with known ocular pathology were excluded. Non-cycloplegic objective refraction was performed followed by subjective refraction. Cycloplegic objective refraction was performed followed by subjective refraction with custom designed artificial apertures. After a washout period of cycloplegic, PMT was performed. The distribution of data was tested using the Kolmogorov–Smirnov test. Depending on the distribution of the data, either parametric or nonparametric test was done.

RESULTS: Fifty-nine eyes of thirty individuals with a mean (±SD) age of 23(±4) years with a male: female ratio of 1:4 participated in this study. A comparison of measures of PMT and subjective refraction with 2, 3, 4, 5, and 6 mm aperture under cycloplegic effect using the Friedman test rendered a Chi square value (df = 5) of 1.92 which was not statistically different ($P = 0.86$).

CONCLUSION: Performing subjective refraction with an appropriate spherical and cylindrical endpoint under cycloplegic effect with appropriate aperture overcomes the necessity of PMT.

Keywords:

Accommodation, artificial pupil, cycloplegics, mydriatics, refraction

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Introduction

Best correction of ametropia is an important part of a comprehensive eye examination, for clear resolution of an optical image on the retina.[1] Cycloplegic refraction is considered as the standard method of rectifying refractive status as it minimizes the effect of ocular accommodation. Clinical studies suggest that cycloplegic refraction should be performed before determining on final spectacle prescription particularly in case of first-time spectacle user, prepresbyopic patients, pediatric population, and patients with accommodative or binocular vision deficits.[2] The process of performing subjective refraction after the washout period of the cycloplegic drug to determine the final spectacle prescription is referred to as postmydriatic test (PMT).[3] In India, traditional practices before spectacle prescription involve performing a noncycloplegic (dry) retinoscopy followed

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by cycloplegic (wet) refraction and a PMT. Apart from the said indications, it is common practice in India to perform cycloplegic refraction followed by an additional visit for PMT before generating spectacle prescription, but there is a lack of evidence on the requirement to perform this test on all the participants. PMT increases the cost of eye care and the inconvenience to the patient because of the additional visit required.[4]

Cycloplegic (wet) refraction is performed using cycloplegic agents such as homatropine, cyclopentolate, and tropicamide.[3] Tropicamide though less effective is a more useful cycloplegic than cyclopentolate as it has less duration of drug action and minimal complications.[3,5] Apart from the loss of accommodation, the predominantly varying parameter during PMT and cycloplegic subjective refraction is pupil size. The pupil size plays an important role in maximizing visual performance and also in determining uncorrected visual acuity as it controls the depth of focus and the extent of optical aberrations.[1,6,7] Therefore, subjective refraction done with optimal artificial pinholes may replace the need for PMT for regular refractive error prescriptions.

Methods

This prospective crossover study was carried out with approval from the Institutional Research and Ethics Committee (Manipal College of Health Professions Research Committee, Kasturba Hospital, Manipal. IEC 179/2014 and approved on 11/3/2014). The study was performed in accordance with the Declaration of Helsinki, and informed consent was obtained from all participants. Fifty-nine participants between 18 and 35 years of age participated in this study. Purposive sampling was used to select the equal distribution of participants with various grades of ametropia (myopia, hyperopia, and astigmatism), and age-matched emmetropes were included. Patients with known ocular diseases, ocular trauma, ocular inflammation, and strabismus were excluded.

All eligible participants underwent the following sequence of examinations. Noncycloplegic objective refraction was performed followed by subjective refraction with an endpoint for cylinder and spherical errors based on Jackson cross cylinder (JCC) and duochrome test, respectively.[8,9] Then, either tropicamide 0.5% or cyclopentolate 0.5% was randomly selected and was instilled thrice with an interval of 5 min. Cycloplegic objective refraction was performed 30 min postinstallation of the third drop followed by subjective refraction which was performed with custom-designed pinholes [Figure 1] in place with endpoint same as noncycloplegic subjective refraction. The diameter of the artificial pinholes ranged from 2 mm to 6 mm in 1 mm steps. Artificial pinholes were custom designed using black opaque material so that unwanted light will not enter except the aperture area.[10] These pinholes were constructed by laser cutting methods and calibrated. All procedures were done by a single examiner (NT). NT was blinded for the type of cycloplegic used and it was instilled by an author (KS).

Uniform room illumination was maintained across the subjective refraction procedures. Photopic pupil sizes were measured using a photorefractor (PlusoptiX A08, Nuremberg, Germany). After the washout period of cycloplegic, PMT was performed. PMT values were compared with the cycloplegic subjective refraction done with different sizes of artificial pinholes. After 1 week, another cycloplegic drug was used and all the procedures [Figure 2] were repeated as per the proposed crossover design based on the clinical study; they found washout period for cycloplegics ≥8 h and tropicamide 7 h, considering that we kept washout period as 1 week.[11]

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) 16.0 version (IBM corporation, New York, USA). The distribution of data was tested using the Kolmogorov–Smirnov test. Depending on the distribution of the data, either parametric or nonparametric test was done.

Results

Fifty-nine participants with a mean (±standard deviation [SD]) age of 23 (±4) years with a male: female ratio of 1:4 participated in this study. Among them, the distribution of ametropia was 30% (n = 18) myopia, 26% (n = 15) hyperopia, 34% (n = 20) simple myopic astigmatism, and 10% (n = 6) emmetropia. There was

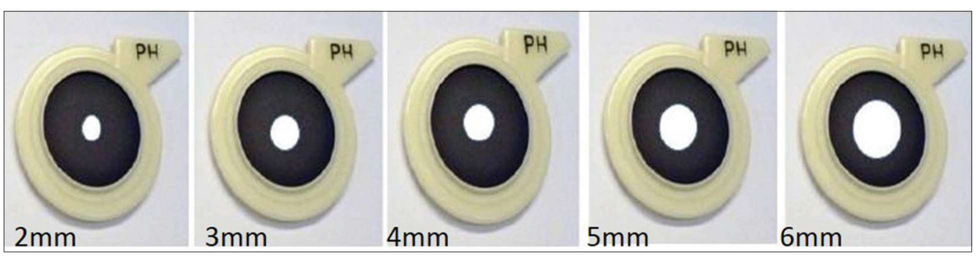

Figure 1: Custom designed apertures of size 2 to 6 mm

Table 1: Distribution of degree of refractive error across ametropes

Ametropia (*n*=53)	Mild±0.25D-±3.000D	Moderate±3.00D-±6.00D	Severe >±6.00D	*P**
Myopia (*n*=18), *n* (%)	6 (33)	6 (33)	6 (33)	0.978
Hyperopia (*n*=15), *n* (%)	5 (33)	5 (33)	5 (33)	
Astigmatism (*n*=20), *n* (%)	8 (40)	7 (35)	5 (25)	

*Chi-square test showed no significant difference

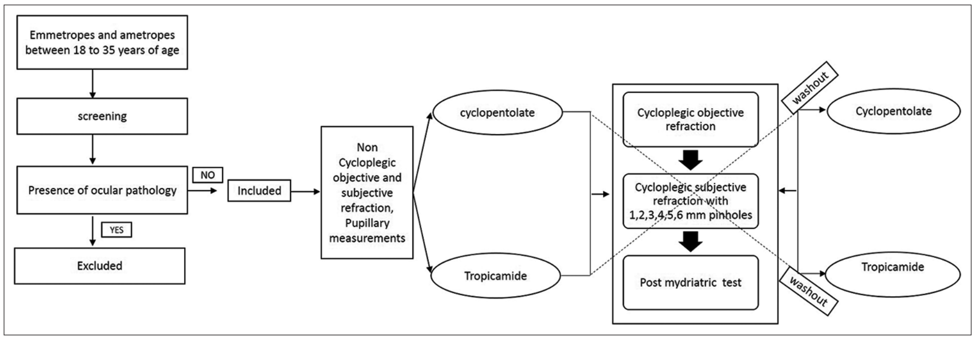

Figure 2: Crossover design of study methodology

no statistically significant difference in the frequency distribution of the degree of refractive error across ametropic groups (*P* = 0.978), as shown in Table 1.

The pupil size across refractive errors was compared using one-way ANOVA as the data were normally distributed, and the difference was not statistically significant (*P* = 0.262), as shown in Table 2.

The difference in refractive error estimated using cyclopentolate and tropicamide was not normally distributed; therefore, based on the Wilcoxon signed-rank test, we found that cycloplegic objective refraction using tropicamide (median: −2.00 D, lower quartile “Q1:” −4.25 D, upper quartile “Q3:” +0.75 D) and cyclopentolate (Median: −2.00 D, Q1: −4.25 D, Q3: +0.50 D) was not statistically significant (*P* = 0.083). As the cycloplegic effect using cyclopentolate and tropicamide was not significantly different, for further analysis of subjective refraction the effect of cyclopentolate was only considered.

A comparison of measures of PMT and subjective refraction with 2, 3, 4, 5, and 6 mm pinholes using the Friedman test rendered a Chi-square value (df = 5) of 1.923 which was not statistically different (*P* = 0.860); however, noncycloplegic subjective refraction was statistically significant from PMT and subjective refraction with 2, 3, 4, 5, and 6 mm pinholes based on the Wilcoxon signed rank test (*P* = 0.008, median difference = 0.25 D). This difference was not clinically significant. The comparison is depicted according to the type of refractive error in Figure 3.

This shows that subjective refraction done with appropriate fogging technique along with refinement of spherical and cylindrical endpoint using duochrome test and JCC is sufficient to arrive at the final spectacle prescription. Second, cycloplegic subjective refraction done with a pinhole in place overcomes the necessity of PMT in adult subjects.

Discussion

A complete cycloplegic examination is a basic procedure in the diagnosis and the treatment of important ophthalmic disorders, particularly in children who are at the critical age of visual maturation and have higher amplitudes of accommodation acting as an obstacle against accurate refraction. However, some traditional practices follow dilated refraction and PMT as part of their regular refraction procedure, thus unduly increasing time for the prescription process. Considering that dilatation is performed as part of a comprehensive eye examination, we propose using artificial pupil size as an alternative to avoid PMT visit in prescribing refractive corrections.

In the present study, we compared the change in refractive errors among the refractive groups of myopia, hyperopia, astigmatism, and emmetropia. Evaluated 59 participants with a mean (±SD) age of 23 (±4) years with a male: female ratio of 1:4 participated in the study. Among them, the distribution of ametropia was 30% (*n* = 18) myopia, 26% (*n* = 15) hyperopia, 34% (*n* = 20) astigmatism, and 10% (*n* = 6) emmetropia. The results showed no statistically significant difference with the median of −0.25 D, with tropicamide (0.5%) and cyclopentolate (0.5%) drug used for dilatation, in all the groups (myopia, hyperopia, astigmatism, and emmetropia).

Dilatation with tropicamide and cyclopentolate drugs did not show any significant change in refractive error among the groups (*P* = 0.083) and emmetropes. The cycloplegic effect of tropicamide and cyclopentolate did not show

Table 2: Pupil size across emmetropes and ametropes

Refractive error (*n*=59)	Mean±SD (mm)	Minimum (mm)	Maximum (mm)	*P**
Emmetropia (*n*=6)	3.83±0.10	3.70	4.00	0.262
Myopia (*n*=18)	3.95±0.12	3.70	4.20	
Hyperopia (*n*=15)	3.86±0.20	3.60	4.20	
Astigmatism (*n*=20)	3.96±0.21	3.60	4.50	

*One-way ANOVA showed no significanst difference in photopic pupil size across ametropes and emmetropes. SD=Standard deviation

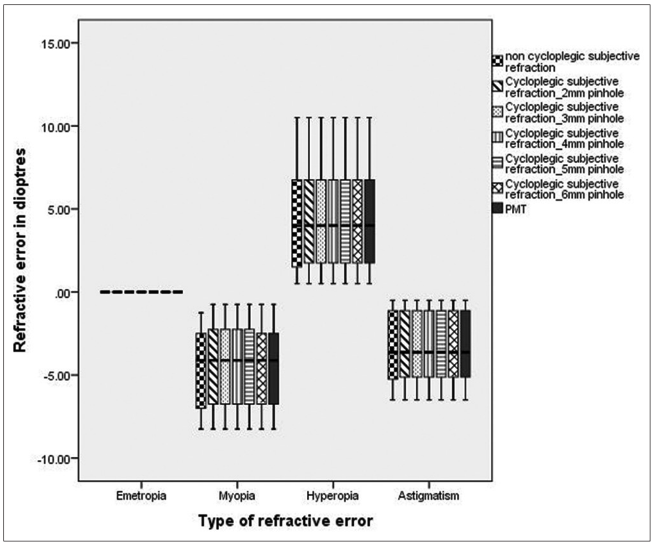

Figure 3: Boxplot depicting the comparison of subjective refractive

any statistically significant difference in refractive error groups and emmetropes, when compared with objective, the subjective refraction and PMT. With these criteria in place, using tropicamide or cyclopentolate for cycloplegic effect drug showed no fluctuation in refractive errors among the groups and emmetropes.

This study found no statistically significant difference between the cyclopentolate and tropicamide. Pi *et al*.[12] had done a study to compare the cycloplegic effect of cyclopentolate and tropicamide using retinoscopy in school children where they observed that the cycloplegic effect of cyclopentolate was stronger than tropicamide. But the difference was less than 0.50D which was considered to be clinically not significant.

Ihekairei[3] compared the cycloplegic action of equiconcentration of tropicamide and cyclopentolate, as well as effects on visual acuity at far and near, near and far phorias, and amplitude of accommodation. The result from this study showed that one drop of 1% solution of tropicamide reduces the quantity and quality of the variables considered; tropicamide though less effective is a more useful cycloplegic than cyclopentolate because its use is not associated with such time and action inconveniences and complications as observed with cyclopentolate (drug effect, near vision blur, and time duration).

In our study, we found that the cycloplegic effect of tropicamide and cyclopentolate did not show fluctuation in groups. The above studies are done in younger children; our inclusion criteria were 18–35 years, and this is also one of the contributing factors for fluctuation for myopia in tropicamide drug compared to cyclopentolate.

We compared the pupil size across refractive errors and found that there was no difference in pupillary size across the refractive error. Furthermore, we compared the refractive error instability among the refractive error using different types of pinhole varying from 2, 3, 4, 5, and 6 mm, and we found that there was no variation (instability) in refractive error using any of these pinholes. Kamiya *et al*.[13,14] compared the effect of pupil size on uncorrected visual acuity in astigmatic eyes. They created with-the-rule and against-the-rule astigmatism of 1, 2, and 3 diopters (D) in each eye and then assessed uncorrected visual acuity using artificial pupils (1–5 mm) in these astigmatic eyes, and they found that the amount of astigmatism and the pupil size can affect uncorrected visual acuity in astigmatic eyes. It was suggested that not only the amount of astigmatism but also the pupil size should be taken into consideration for acquiring better visual performance in astigmatic eyes.

Conclusion

There was no significant difference in refractive error under the effect of cyclopentolate and tropicamide. Performing subjective refraction with an appropriate spherical and cylindrical endpoint under cycloplegic effect with pinholes of size 2, 3, and 4 mm certainly circumvents the necessity of PMT. Smaller sample size in subgroups limits subanalysis specific to refractive error type.

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Conflicts of interest
The authors declare that there are no conflicts of interests of this paper.

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