·Clinical Research·

Comparison of non-cycloplegic photorefraction, cycloplegic photorefraction and cycloplegic retinoscopy in children

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Abstract

• **AIM: To compare the results of noncycloplegic photorefraction, cycloplegic photorefraction and cycloplegic refraction in preschool and non-verbal children.**

• **METHODS: One hundred and ninety-six eyes of 98 children (50 females, 48 males) were included in the study. Firstly, non-cycloplegic photorefraction was achieved with Plusoptix A09; secondly, cycloplegic photorefraction was carried out with Plusoptix A09 after 10min cyclopentolate. Finally, 30min after instillation of twice cyclopentolate, cycloplegic refraction was obtained with autorefraction and/or standard retinoscopy. Spheric equivalent, spheric power, cylindric power and cylindrical axis measurements were statistically compared.**

• **RESULTS: The mean age was 28.8±18.5mo (range 12-72mo). The differences in spherical equivalent, spheric power and cylindrical power measured by the three methods were found statistically significant (*P*<0.05). The spherical equivalent and spheric power measured by cycloplegic photorefraction were statistically higher than the measurements of the other methods (*P*<0.05). The cylindrical power measured by cycloplegic refraction was statistically lower than the measurements of the photorefraction methods (*P*<0.05). There was no significant difference in cylindrical axis measurements between three methods (*P*>0.05).**

• **CONCLUSION: For the determination of refractive errors in children, the Plusoptix A09 measurements give incorrect results after instillation of cyclopentolate. Additionally, the cylindrical power measured by Plusoptix A09 with or without cycloplegia is higher. However, the non-cycloplegic Plusoptix A09 measures spheric equivalent and spheric power similar to cycloplegic refraction measurements in preschool and non-verbal children.**

• **KEYWORDS:** cyclopentolate; cycloplegia; photorefraction; photoretinoscopy; Plusoptix; retinoscopy; refraction

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INTRODUCTION

Preschool vision screening aims to detect amblyopic and related conditions such as strabismus, anisometropia, and refractive errors. Photorefraction is a screening method developed for the determination of refractive errors and a convenient way to determine refractive state from a distance. Therefore, it is useful for measuring infants and uncooperative patients. Photorefraction is unique in enabling the measurement of accommodation, vergence, and pupil size in both eyes simultaneously, objectively, remotely (typically the camera is placed 1 m from the eyes) and continuously. Photoscreening is more time efficient than traditional screening. Moreover, photorefraction is a technique that can measure refractive errors without administering cycloplegia [1-3].

Plusoptix devices are the commercially available instrument to use photorefraction. They are marketed principally as a vision screener, for the objective measurement of refractive error. Plusoptix devices detect vision disorders in children to fight amblyopia, provide full refraction information during eye exams and help in researching the functioning of the eye [4-7].

Table 1 Comparison of the spherical equivalent, spheric power, cylindrical power and cylindrical axis measurements between three methods $\bar{x} \pm s$

Methods	Spherical equivalent	Spheric power	Cylindrical power	Cylindrical axis	
				J_0	J_{45}
Non-cycloplegic photorefraction	0.42±1.59	1.03±1.65	1.12±0.68	-0.018±0.30	0.026±0.16
Cycloplegic photorefraction	[1]1.15±1.91	[1]1.71±1.9	1.06±0.70	-0.032±0.21	0.024±0.23
Cycloplegic refraction	0.76±1.77	1.10±1.68	[1]0.71±0.5	-0.030±0.13	0.018±0.12
[2]P	<0.05	<0.05	<0.05	>0.05	>0.05

SD: Standard deviation; [1]Statistically significant than the others; [2]Related Sample One-Way ANOVA with Bonferroni-adjusted pairwise comparisons.

However, its reliability and validity has been questioned. The aim of this study was to compare the measurements of non-cycloplegic photorefraction, cycloplegic photorefraction and cycloplegic refraction made in preschool and non-verbal children.

SUBJECTS AND METHODS

Participants were recruited from the Zekai Tahir Burak Women's Health Education and Research Hospital. Children were excluded from the study if they had ptosis, strabismus, opacities of the lens, retinal abnormalities. Children with mental retardation and children were not be tested with photorefraction were also excluded. According to the recommendations of the manufacturer the eyes with spherical range of -7.00 to +5.00 D and a cylinder range of -7.00 to +5.00 D were included to the study.

All patients underwent a complete ophthalmologic examination including a cover and alternating cover test, evaluation of eye movements, observation of corneal light reflex (Hirschberg's method) at 30 cm, examination of anterior segment and funduscopy by an indirect ophthalmoscope. All measurements were performed in the following order. Firstly, non-cycloplegic photorefraction was achieved with Plusoptix A09 (Plusoptix GmbH, Nürnberg, Germany). Secondly, after 10min of instilling one drop of cyclopentolate 1% (cyclopentolate 0.5% was instilled for the children under 10 kg) in each eye cycloplegic photorefraction was carried out with Plusoptix A09. Finally, 30min after instillation of twice cyclopentolate, cycloplegic refraction was obtained with autorefraction and/or standard retinoscopy. Standard retinoscopy was performed in inaccordant children with autorefraction using a retinoscope (Welch Allyn Elite Retinoscope, Welch Allyn Inc., NY, USA). Autorefraction was performed using Righton Speedy K Auto Refractor/ Keratometer (Vision Systems Inc., Tarpon Springs, FL, USA).

Spheric equivalent [spherical equivalent=sphere+(cylinder/2)], spheric power, cylindrical power and cylindrical axis measurements were compared. Astigmatism was recorded and evaluated in minus cylinder notations. The axis component was converted into a vector representation for analysis: Jackson cross cylinder at axis 0° with power J_0 = -(cylinder/2) cos(2Xaxis); Jackson cross cylinder at axis 45° with power J_{45} = -(cylinder/2) sin(2Xaxis)[8].

This study has been approved by the local ethics committee and has been performed in accordance with the ethical standards laid down in the Declaration of Helsinki. The parents or guardians of all children gave their informed consent prior to their inclusion in the study.

Statistical Analysis Results are reported as the mean ± standard deviation (SD), frequency and percentages. Differences between the measurement methods were tested for significance by Related Sample One-Way ANOVA with Bonferroni-adjusted pairwise comparisons. Differences were considered significant at P<0.05. Statistical analysis was performed using a computer package program SPSS 16.0 (SPSS Inc. Chicago, IL, USA).

RESULTS

A total of 110 children were recruited. Cycloplegic photorefraction was not possible in 12 children (10.9%) due to large pupil size. After excluding these cases, data from 196 eyes of 98 children (50 females, 48 males) were analyzed. The mean age was 28.8±18.5mo (range 12-60mo). Cycloplegic refraction was performed using an autorefractometer in 66 eyes (33.7%), and by retinoscopy in 130 eyes (66.3%).

The differences in spherical equivalent, spheric power and cylindrical power measured by the three methods were found statistically significant (P<0.05). The spherical equivalent and spheric power measured by cycloplegic photorefraction were statistically higher than the measurements of the other methods (P<0.05). The cylindrical power measured by cycloplegic refraction was statistically lower than the measurements of the photorefraction methods (P<0.05). There was no significant differences in cylindrical axis measurements between three methods (P>0.05, Table 1).

DISCUSSION

It is important an accurate measurement of the refractive errors for prevention of amblyopia in children. Vision screening in childhood aims to detect several disorders resulting in vision defects. Because of the large working distance (approximately 1 m), photorefraction is applicable to children who are afraid of examinations and disabled patients. It has advantageous due to allow short examination duration and binocular measurement. As a portable device it can be used for screening programme of amblyopia and/or anisometropia[9-11].

The measuring principle of the Plusoptix A09 is based on eccentric photo-retinoscopy. Infrared light is projected through the pupils onto the retina. Depending on the refractive error, the reflected light forms a specific brightness pattern within the pupil. The spherical refraction is calculated based in this crescent pattern. To determine cylinder and axis the same measurement is repeated in three meridians. The measurement with infrared light is completely innocuous. Infrared light is also contained in daylight and not visible. The Plusoptix is an automated photoscreening device that takes multiple images in less than 30s, determining a noncycloplegic refraction. Sensitivity and specificity suggests that testing the Plusoptix for applications in a general screening environment should be considered[12,13].

In the present study, the Plusoptix A09 without cycloplegia yielded good spheric equivalent and spheric power measurements. Schimitzek and Haase [14] reported that the reliability of the photorefractor which was the subject of the evaluation in detecting amblyogenic ametropia was comparable to that of other devices described previously in the literature. Günaydin *et al* [15] compared the refractive errors measured by Topcon RM-A7000B, Nikon Retinomax autorefractor and Plusoptix S08 videoretinoscopy in school-age children. They demonstrated that Plusoptix S08 may be used for screening due to give accurate measurements noncycloplegically[15].

This investigation has shown that photorefraction with cycloplegia leads to be overestimated the spherical equivalent and spheric power. Because cycloplegia produces mydriasis as well, accuracy of refraction with and without cycloplegia is also influenced by the pupil diameter. Ayse *et al* [16] reported that spherical equivalent values obtained using Plusoptix S04 with or without cycloplegia is more in in young patients. On the other hand, Schimitzek and Lagrèze[17] showed that without cycloplegia, the spherical equivalent of the PowerRefractor tends to be underestimated due to uncontrolled accommodation, especially in children. However, 12 of 110 (10.9%) children could not measured by photorefraction due to cycloplegia produced mydriasis as well. According to our experience in this study, it is not possible to measure refractive errors by Plusoptix A09 after after instillation of cyclopentolate.

In this study, the cylindrical power measured by Plusoptix A09 with or without cycloplegia was found higher compared with cycloplegic refraction. Erdurmus *et al* [18] compared the results of photorefraction measurement obtained with a Plusoptix CR03 to those of cycloplegic retinoscopy as a standard refraction method in children and found statistically significant differences between the techniques in terms of cylindrical power and axis. Schimitzek and Lagrèze [17] recommended the examination of cylinder power and axis by Plusoptix A09 prior to cycloplegia because of the reducing precision in determination of cylinder power and axis. They stated that the PowerRefractor assessed cylinder power and axis more precise when the pupils of the eyes were unaltered by cycloplegic drugs. It was explained that peripheral aberrations of cycloplegic pupils that disturb the measurement [17]. The cylindrical axes measurements were similar with three methods. Recently in most studies cylindric axes were found consistent between PowerRefractor and other autorefractometer[19,20].

Accommodation, especially in children, affects the spherical equivalent values playing significant role in measurements refraction errors. Therefore, the children age groups and patients with high spherical power need to be re-evaluated by cycloplegic retinoscopy. Cycloplegic refraction remains the gold standard for detecting refractive errors. The limitations of this study include the small number of patients, investigation both eyes of subjects. In this study, we did not able to randomize the eyes. However, including both eyes provides a higher statistical power.

Definitely, cycloplegic retinoscopy using cyclopentolate is the gold standard by which other methods are compared. In conclusion, for the determination of refractive errors in children, the PowerRefractor is a practical and effective hand-held autorefractor for the measurements of refractive errors. In this study we found that the non-cycloplegic measurements of spheric equivalent and spheric power by Plusoptix A09 are correct compared with cycloplegic refraction. However, the instillation of cyclopentolate leads to increased spheric equivalent, spheric power and cylindrical power measured by Plusoptix A09. Additionally, the cylindrical power measured by Plusoptix A09 with or without cycloplegia is higher.

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