·Clinical Research·

Comparison of the Retinomax hand-held autorefractor versus table-top autorefractor and retinoscopy

Ibrahim Tuncer [1], Mehmet Ozgur Zengin [2], Eyyup Karahan [1]

[1]Alfagoz Eye Center, Balcova 35330, Izmir, Turkey
[2]Department of Ophthalmology, Izmir University Faculty of Medicine, Karsiyaka 35510, Izmir, Turkey.
Correspondence to: Ibrahim Tuncer. Alfagoz Eye Center, Balcova 35330, Izmir, Turkey. ibrahimtuncer106@gmail.com

Abstract

- **AIM:** To compare noncycloplegic and cycloplegic results of Retinomax measurements with findings achieved after cycloplegia using table –top autorefractor and retinoscopy.

- **METHODS:** The study included 127 patients (mean age 96.7mo, range 21 to 221). Retinomax (Rmax) (Nikon Inc., Japan) was used to obtain noncycloplegic refraction. Under cycloplegia, refraction was measured with Rmax, table –top autorefractor (TTR) (Nikon NRK 8000, Inc., Japan) and retinoscopy. The values of sphere, spherical equivalent, cylinder and axis of cylinder were recorded for Rmax, TTR and retinoscopy in each eye. All results were analyzed statistically.

- **RESULTS:** The mean spheric values (SV), spherical equivalent values (SEV) and cylindrical values (CV) of the noncycloplegic Rmax (SV: 0.64 D, SEV: 0.65 D and CV: 0.03 D, respectively) were found to be significantly lower than cycloplegic TTR (1.43 D, 1.38 D and 0.3 D; P=0.012, P=0.011 and P=0.04, respectively) and retinoscopy (1.34 D, 1.45 D and 0.23 D; P =0.04, P =0.002 and P =0.045, respectively). Mean cycloplegic SV, SEV, CV were not significantly different between Rmax and TTR, Rmax and retinoscopy, TTR and retinoscopy. Cycloplegic or noncycloplegic axis values were not different between any method.

- **CONCLUSION:** Rmax may be used successfully as a screening tool but may not be accurate enough for actual spectacle prescription. Cycloplegic Rmax measurements may be able to identify refractive error in children because of approximate results to retinoscopy.

- **KEYWORDS:** autorefractor; hand-held refractors; retinoscopy; Retinomax

INTRODUCTION

A bnormal refractive errors in childhood may lead to amblyopia [1,2]. Early detection and prompt treatment of refractive errors can prevent amblyopia and strabismus[1,3]. For this reasons, to identify and correct the refractive errors as early as possible is crucial. The traditional method for identify refractive errors in children includes noncycloplegic and cycloplegic retinoscopy which performed by skilled experienced ophthalmologist. Conventional retinoscopy requires long training for examiners and cooperative patients. Therefore, there has been an effort to develop techniques and instruments that permit detection of refractive errors with minimal requirement of cooperation in children. Autorefractors have been used for some years but may not be suitable for use in small children becuse of their immobility[4-8]. Currently, hand held autorefractors (HHR) allow refractive errors to be estimated rapidly. Several authors have already studied its accuracy and reproducibility as a screening device[7-11].

The aim of this study was to investigate the accuracy of the Retinomax, to compare results of Retinomax measurement in children under noncycloplegic condition with findings achieved after cycloplegia using table-top autorefractor and retinoscopic results of an experienced pediatric ophthalmologist and to asses the agreement between these results.

SUBJECTS AND METHODS

One hundred and twenty-seven consecutive patients were evaluated for ophthalmological assesment. Written informed consent was obtained from parents of all children. The conduct of the study followed the tenets of the Declaration of Helsinki. This study was conducted in accordance with ethical guidelines. Visual acuities were obtained with Snellen letters, Allen pictures or Teller acuity card according to children ages. After initial ocular and systemic history visual acuities recorded, the full ophthalmic examination includes cover test, TNO stereotest and anterior segment examination.

We excluded subjects with squint, media opacity, amblyopia or any cause of decreased vision before the study. Retinomax (Rmax) (Nikon Inc., Japan) was used to obtain noncycloplegic refraction. Cycloplegia was achieved by instillation of one drop of 1% cyclopentolate and one drop 1% tropicamid 5min apart. Refraction was measured with Rmax and table-top autorefractor (TTR) (Nikon NRK 8000, Inc., Japan) 45min after the last instillation. Subsequently, the child was manually refracted and refined by an experienced pediatric ophthalmologist who was masked to previous autorefractor's results. The refined refraction was accepted as the 'gold standard'. All measurements were made during same consultation. The values of sphere, spherical equivalent, cylinder and axis of cylinder were recorded for Rmax, TTR and retinoscopy in each eye. The spherical equivalent values (SEV) was calculated as the sum of the sphere plus half the cylindrical power. The pateints who could not be refracted by autorefractor because of poor compliance or whose measurements' reliability was under <8 were excluded. Moreover, in cycloplegic retinoscopic examination, the refraction results of -1.00 D or greater, +2.50 D or greater, and +1.00 D or greater were defined as myopia, hyperopia and astigmatism, respectively. The diagnostic accuracy of refractive errors was assessed by sensitivity and specificity.

SPSS statistical software, version 16.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Refraction techniques were compared by analysis of variance test (ANOVA). A variance ratio (F) was calculated to determine overall statistical differences. Paired t-test was then used to investigate individual statistical differences between the methods. A P-value of <0.05 was considered statistically significant.

RESULTS

One hundred and twenty-seven patients (254 eyes) were evaluated as a study group. The mean age of patients was ranged from 21-221mo (mean 96.7mo). Sixty-two of patients (48.8%) were female, 65 of patients (51.2%) male.

In noncycloplegic children, using the Rmax, the mean spherical value (SV) was 0.64 D (range -10.50-14.00), mean cylindrical value (CV) was 0.03 D (range -3.50-5.00) and mean axis measurement was 71.9° (range 0-180). The mean SEV was 0.65 D (range -11.75 to 15.88). According to SEV, 82 (32.3%) of eyes were myopic, 111 (43.7%) were hyperopic and 61 (24%) were plano. Astigmatism was found in 91 (35.8%) of eyes, 67 (73.6%) of these eyes had a CV more than 1.00 D.

In cycloplegic measurements, using the Rmax, the mean SV was 1.27 D (range -10.00-15.00), mean CV was 0.18 D (range -3.75-5.00) and mean axis measurement was 74.9°

Table 1 The mean sphere, spherical equivalent, cylinder and axis values

Mean values	Rmax (NC)	Rmax (C)	TTR	R
Sphere	+0.64	+1.27	+1.28	+1.34
Spherical equivalent	+0.65	+1.36	+1.43	+1.45
Cylinder	+0.03	+0.18	+0.3	+0.23
Axis	71.9°	74.9°	81.4°	75.9°

Rmax: Retinomax; Noncycloplegic: NC; Cycloplegic: C; TTR: Table-Top Autorefractor; R: Retinopathy.

(range 0-180). The mean SEV was 1.36 D (range -11.75- 15.88). According to SEV, 49 (19.3%) of eyes were myopic, 153 (60.3%) were hyperopic and 52 (20.4%) were plano. Astigmatism was found in 81 (33.1%) of eyes, 70 (83.3%) of these eyes had a CV more than 1.00 D.

The mean SV recorded with TTR was 1.28 D (range -10.75 -14.00), mean CV was 0.3 D (range -3.00-4.75) and mean axis measurement was 81.4° (range 0-180). The mean SEV was 1.43 D (range -12.63-14.75). A myopic SEV was found in 45 (17.7%) of the eyes, 153 (60.2%) were hyperopic and 56 (22.1%) plano. Astigmatism was diagnosed in 78 (30.7%) of eyes, 54 (69.2%) of these eyes had a CV more than 1.00 D.

The mean SV recorded using retinoscopy was 1.34 D (range -9.00-13.00), mean CV was 0.23 D (range -3.50-5.00) and mean axis measurement was 75.9° (range 0-180). The mean SEV was 1.45 D (range -10.00-14.00). According to SEV, 38 (15.0%) of eyes were myopic, 168 (66.1%) were hyperopic and 48 (18.9%) were plano. Astigmatism was found in 83 (32.7%) of eyes, 33 (39.8%) of these eyes had a CV more than 1.00 D. These findings were summarized in Table 1.

ANOVA testing of SV revealed an F ratio of 3.905 (P= 0.009) which indicates an overall difference. Comparison of noncycloplegic Rmax with retinoscopy based on SV showed statisttically significant difference (P=0.040). Also, there was statistical difference between noncycloplegic Rmax and TTR results (P=0.012). The difference among cycloplegic Rmax, TTR and retinoscopy measurements was not statistically significant (P>0.05, for all) (Table 2).

ANOVA testing for CV did not show any statistical differences (F=1.866, P=0.136). Statistically significance between the noncycloplegic Rmax versus TTR and noncycloplegic Rmax versus retinoscopy were demonstrated (P=0.040 and P=0.045, respectively). The difference among cycloplegic Rmax, TTR and retinoscopy measurements was not statistically significant (P>0.05, for all) (Table 3).

ANOVA testing for SEV indicated an overall statistical difference(F=7.489, P=0.01). Comparison of noncycloplegic Rmax versus TTR and noncycloplegic Rmax versus retinoscopy was statistically different (P=0.011 and P=0.002, respectively). The difference between cycloplegic Rmax,

Table 2 Statistical analysis of data for spherical values. Agreement between different techniques

ANOVA for sphere		t-test for sphere				
		Rmax(NC) vs TTR	Rmax(NC) vs R	Rmax(C) vs TTR	Rmax(C) vs R	TTR vs R
F=3.905	d	0.65	0.71	0.11	-0.07	-0.06
P=0.009	P	0.012	0.040	0.787	0.125	0.145
	95%CI	0.0146-1.153	0.224-1.204	-0.068-0.089	-0,173-0.212	-0.152-0.227
Different		Different	Different	Similar	Similar	Similar

d: Mean difference between measurement technique; ANOVA: Analysis of variance test; CI: Confidence Interval; F: Variance ratio, Rmax: Retinomax; NC: Noncycloplegic; C: Cycloplegic; TTR: Table top autorefractor; R: Retinoscopy.

Table 3 Statistical analysis of data for cylinder values. Agreement between different techniques

ANOVA for cylinder		t-test for cylinder				
		Rmax(NC) vs TTR	Rmax(NC) vs R	Rmax(C) vs TTR	Rmax(C) vs R	TTR vs R
F=1.866	d	0.27	0.20	0.12	-0.04	0.06
P=0.136	P	0.040	0.045	0.178	0.420	0.470
	95%CI	0.078-0.329	0.005-0.404	-0.051-0.275	-0.165-0.692	-0.111-0.239
Similar		Different	Different	Similar	Similar	Similar

d: Mean difference between measurement technique; ANOVA: Analysis of variance test; CI: Confidence Interval; F: Variance ratio; Rmax: Retinomax; NC: Noncycloplegic; C: Cycloplegic; TTR: Table-top autorefractor; R: Retinoscopy.

Table 4 Statistical analysis of data for spherical equivalent values. Agreement between different techniques

ANOVA for spherical equivalent		t-test for spherical equivalent				
		Rmax(NC) vs TTR	Rmax(NC) vs R	Rmax(C) vs TTR	Rmax(C) vs R	TTR vs R
F=7.489	d	0.73	0.85	0.14	-0.14	-0.13
P=0.01	P	0.011	0.002	0.736	0.625	0.657
	95%CI	0.165-1.29	0.313-1.387	-0.068-0.096	-0.239- -0.034	-0.220- -0.024
Different		Different	Different	Similar	Similar	Similar

d: Mean difference between measurement technique; ANOVA: Analysis of variance test; CI: Confidence Interval; F: Variance ratio; Rmax: Retinomax; NC: Noncycloplegic; C: Cycloplegic; TTR: Table-top autorefractor; R: Retinoscopy.

Table 5 Statistical analysis of data for axis values. Agreement between different techniques

ANOVA for axis		t-test for axis				
		Rmax(NC) vs TTR	Rmax(NC) vs R	Rmax(C) vs TTR	Rmax(C) vs R	TTR vs R
F=1.721	d	9.56	4,03	6.44	9.13	-5.53
P=0.161	P	0.06	0.260	0.190	0.792	0.114
	95%CI	-0.24 -19.35	-2.98-11.03	-3.20-16.09	-5.88-7.71	-12.39 -1.33
Different		Similar	Similar	Similar	Similar	Similar

d: Mean difference between measurement tecnique; ANOVA: Analysis of variance test; CI: Confidence Interval; F: Variance ratio; Rmax: Retinomax; NC: Noncycloplegic; C: Cycloplegic; TTR: Table-top autorefractor; R: Retinoscopy.

Table 6 The sensitivity and specificity for cycloplegic Retinomax (Rmax) and table-top autorefractor (TTR)   %

Parameters	Sensitivity (Rmax)	Specificity (Rmax)	Sensitivity (TTR)	Specificity (TTR)
Hyperopia	93	79	92	72
Myopia	68	100	75	100
Astigmatism	72	86	70	88

TTR and retinoscopy measurements was not statistically significant (P>0.05, for all) (Table 4).

ANOVA testing for axis values did not show any statistical differences (F=1.721, P=0.161). Also, there was no statistical difference between any method in t-test in term of axis values (Table 5).

The sensitivity and specificity are shown for cycloplegic Rmax and TTR (Table 6).

DISCUSSION

Screening of amblyopia is difficult because visual acuity cannot be easily measured in children. Acuity cards are not accurate for the diagnosis of amblyopia and are difficult to use in the community screening situation where testing conditions are often less than ideal. Screening of children might best be carried out by detecting the risk factors for amblyopia such as strabismus and abnormal refractive errors

rather than directly measuring visual acuity. HHR would be useful for screening for abnormal refractive errors, in addition to its possible use in clinical management[12-14].

The Rmax is a hand held instrument designed to provide a rapid estimate of refractive error. The portability and ease of use of the Rmax suggest that it might be a useful tool for providing definitive measurements of refractive error under cycloplegic conditions for use in research studies, and may be useful for screening young children for high refractive errors under noncycloplegic conditions [4]. But some studies showed that screening with the Rmax under noncycloplegic conditions resulted in overcorrection and too many false-positive referrals[15].

El-Defrawy et al [5] reported that the results of Rmax and retinoscopy under cycloplegia were similar for SV but the difference between the mean CV obtained by two methods was statistically significant, on the other hand this difference was clinically insignificant (0.23 D). And results using the Rmax without cycloplegic were grossly inaccurate. Kallay et al [16] reported high agreement of three refractive measurements (sphere, cylinder and axis) between the on table autorefractor and Rmax under cycloplegia.Liang et al[8] reported the difference of SV under the cycloplegic condition was significantly different from that under noncycloplegic condition by Rmax and TTR (0.59 D). Although this difference is within a clinical acceptable range, SV in the cycloplegic eyes measured by the 2 types of autorefractors were almost identical. Difference of cylinder and axis was not significantly in either cycloplegic or noncycloplegic condition.

Prabakaran coworkers[11] stated that mean SEV obtained from Rmax with cycloplegia (0.8 D) was significantly less than retinoscopy (1.09 D) while no significant difference was noted between TTR and retinoscopy. Astigmatism measured with Rmax (-0.89 D) and TTR (-0.83 D) were significantly greater than that retinoscopy (-0.58 D).

In present study, the mean SEV with cycloplegic Rmax 0.09 D more myopic than retinoscopy, but this diffrence was not statistically significant. Also, the difference of mean SV, SEV, CV and axis values under cycloplegia were not statistically significant between any methods (Rmax, TTR and retinoscopy).

Previous studies demonstrated Rmax measurements without cycloplegy were grossly inaccurate [5,15]. Similarly, the current study showed that noncycloplegic Rmax measurements (SV, SEV and CV) were significantly lower than all cycloplegic measurement methods.

A few studies involving cyclopleged children where little difference was noted in spherical, cylinder or axis

measurements for Rmax, TTR and retinoscopy [15-17]. In addition, Rmax, TTR and retinoscopy measurement with cycloplegic were revealed likely results most of studies in literature[5,8,11,16,18,19].

Refractive errors definition differs between studies, there are wide ranges for sensitivity and specificity ratios were shown in these studies. Choong et al [15] reported the sensitivity and specificity in detecting myopia greater than 0.50 D was 100% and 51%, whereas that for hyperopia greater than 0.50 D was 84% and 82%, respectively. The Vision In Preschool study group reported a sensitivity of 66% for significant refractive errors with Rmax [20]. In our study, sensitivity and specificity for the Rmax were 68% and 100% for myopia, 93% and 79% for hyperopia and 72% and 86% for astigmatism, respectively. Similar to other studies we found that, the Rmax had slightly lower sensitivity for detecting myopia[9,21-23].

In conclusion, noncycloplegic Rmax values were significantly 'minus'. This difference was 0.80 D. This support the argument that, Rmax might be used successfully as a screening tool but may not be accurate enough for actual spectacle prescription. The accuracy of the Rmax and TTR when compared with retinoscopy were similar under cycloplegic condition. Because of the reliable results of measurements and easier to use in detection of refractive errors, cycloplegic Rmax can be used as an alternative method to cycloplegic retinoscopy in children.

ACKNOWLEDGEMENTS

REFERENCES

1 Khandekar R, Parast N, Arabi A. Evaluation of 'vision screening' program for three to six-year-old children in the Republic of Iran. *Indian J Ophthalmol* 2009;57(6):437-442

2 Harvey EM. Development and treatment of astigmatism-related amblyopia. *Optom Vis Sci* 2009;86(6):634-639

3 van Leeuwen R, Eijkemans MJ, Vingerling JR, Hofman A, de Jong PT, Simonsz HJ. Risk of bilateral visual impairment in individuals with amblyopia: the Rotterdam study. *Br J Ophthalmol* 2007;91(11):1450-1451

4 Harvey EM, Miller JM, Wagner LK, Dobson V. Reproducibility and accuracy of measurements with a hand held autorefractor in children. *Br J Ophthalmol* 1997;81(11):941-948

5 El-Defrawy S, Clarke WN, Belec F, Pham B. Evaluation of a hand-held autorefractor in children younger than 6. *J Pediatr Ophthalmol Strabismus* 1998;35(2):107-109

6 Trager MJ, Dirani M, Fan Q, Gazzard G, Selvaraj P, Chia A, Wong TY, Young TL, Varma R, Saw SM. Testability of vision and refraction in preschoolers: the strabismus, amblyopia, and refractive error study in singaporean children. *Am J Ophthalmol* 2009;148(2):235-241

7 Cordonnier M, De Maertelaer V. Comparison between two hand-held autorefractors: the Sure-Sight and the Retinomax *Strabismus* 2004;12(4):261-274

8 Liang CL, Hung KS, Park N, Chan P, Juo SH. Comparison of measurements of refractive errors between the hand-held Retinomax and on-table autorefractors in cyclopleged and noncyclopleged children. *Am J Ophthalmol* 2003;136(6):1120-1128

9 Oral Y, Gunaydin N, Ozgur O, Arsan AK, Oskan S. A Comparison of Different Autorefractors With Retinoscopy in Children. *J Pediatr Ophthalmol Strabismus* 2012;49(6):370-377

10 Ying GS, Maguire M, Quinn G, Kulp MT, Cyert L; Vision In Preschoolers (VIP) Study Group. ROC analysis of the accuracy of Noncycloplegic retinoscopy, Retinomax Autorefractor, and SureSight Vision Screener for preschool vision screening. *Invest Ophthalmol Vis Sci* 2011; 52(13):9658-9664

11 Prabakaran S, Dirani M, Chia A, Gazzard G, Fan Q, Leo SW, Ling Y, Au Eong KG, Wong TY, Saw SM. Cycloplegic refraction in preschool children: comparisons between the hand-held autorefractor, table-mounted autorefractor and retinoscopy. *Ophthalmic Physiol Opt* 2009;29 (4): 422-426

12 Borchert M, Wang Y, Tarczy-Hornoch K, Cotter S, Deneen J, Azen S, Varma R; MEPEDS Study Group. Testability of the Retinomax autorefractor and IOLMaster in preschool children: the Multi-ethnic Pediatric Eye Disease Study. *Ophthalmology* 2008;115(8):1422-1425

13 Dahlmann-Noor AH, Vrotsou K, Kostakis V, Brown J, Heath J, Iron A, McGill S, Vivian AJ. Vision screening in children by Plusoptix Vision Screener compared with gold-standard orthoptic assessment. *Br J Ophthalmol* 2009;93(3):342-345

14 Pai AS, Rose KA, Samarawickrama C, Fotedar R, Burlutsky G, Varma R, Mitchell P. Testability of refraction, stereopsis, and other ocular measures in preschool children: the Sydney Paediatric Eye Disease Study. *J AAPOS* 2012;16(2):185-192

15 Choong YF, Chen AH, Goh PP. A comparison of autorefraction and subjective refraction with and without cycloplegia in primary school

children. *Am J Ophthalmol* 2006;142(1):68-74

16 Kallay OP, Cordonnier MJ, Dramaix MM. Cycloplegic refractive errors in children: comparison of a standard and a hand-held refractor. *Strabismus* 1998;6(1):3-7

17 Liang CL, Hung KS, Park N, Chan P, Juo SH. Comparison of the handheld Retinomax K-Plus2 and on-table autokeratometers in children with and without cycloplegia. *J Cataract Refract Surg* 2004;30(3):669-674

18 Schmidt-Bacher AE, Kahlert C, Kolling G. Accuracy of two autorefractors-Pediatric Autorefractor plusoptiX and Retinomax--in cycloplegic children in comparison to retinoscopy. *Klin Monbl Augenheilkd* 2010;227(10):792-797

19 Vision in Preschoolers (VIP) Study Group, Ciner E, Carter A, Ying GS, Maguire M, Kulp MT. Comparison of the Retinomax and Palm-AR Auto-Refractors: a pilot study. *Optom Vis Sci* 2011;88(7):830-836

20 Ying GS, Kulp MT, Maguire M, Ciner E, Cyert L, Schmidt P; Vision in Preschoolers Study Group.Sensitivity of screening tests for detecting vision in preschoolers-targeted vision disorders when specificity is 94%. *Optom Vis Sci* 2005;82(5):432-438

21 Gole GA, Schluter PJ, Hall J, Colville D. Comparison of the Retinomax autorefractor with hand-held retinoscopy in 1-year-old infants. *Clin Exp Ophthalmol* 2003;31(4):341-347

22 Farook M, Venkatramani J, Gazzard G, Cheng A, Tan D, Saw SM. Comparisons of the handheld autorefractor, table-mounted autorefractor, and subjective refraction in Singapore adults. *Optom Vis Sci* 2005;82(12): 1066-1070

23 Paff T, Oudesluys-Murphy AM, Wolterbeek R, Swart-van den Berg M, de Nie JM, Tijssen E, Schalij-Delfos NE. Screening for refractive errors in children: the plusoptiX S08 and the Retinomax K-plus2 performed by a lay screener compared to cycloplegic retinoscopy. *J AAPOS* 2010;14 (6): 478-483