Screening for refractive errors in children: accuracy of the hand held refractor Retinomax to screen for astigmatism

Monique Cordonnier, Michèle Dramaix

Abstract

Aims—To assess the reliability of the hand held automated refractor Retinomax in measuring astigmatism in non-cycloplegic conditions. To assess the accuracy of Retinomax in diagnosing abnormal astigmatism in non-cycloplegic refractive screening of children between 9 and 36 months.

Methods—Among 1205 children undergoing a non-cycloplegic refractive screening with Retinomax, 299 (25%) had repeated non-cycloplegic measurements, 302 (25%) were refracted under cycloplegia using the same refractor, and 88 (7%) using retinoscopy or an automated on table refractor. The reproducibility of non-cycloplegic cylinder measurement was assessed by comparing the cylindrical power and axis values in the 299 repeated measurements without cycloplegia. The influence of the quick mode on cylinder measurement was analysed by comparing the cylinder and axis value in 93 repeated measurements without cycloplegia where normal mode was used in one measurement and quick mode in the other. Predictive values of the refractive screening were calculated for three different thresholds of manifest astigmatism (≥1.5, ≥1.75, and ≥2 D) considering as a true positive case an astigmatism ≥2 D under cycloplegic condition (measured by retinoscopy, on table, or hand held refractor).

Results—The 95% limits of agreement between two repeated manifest cylinder measurements with Retinomax attained levels slightly less than plus or minus 1 D. The 95% limits of agreement for the axis were plus or minus 46°. The comparison of non-cycloplegic measurements in the quick and normal mode showed no significant difference and 95% limits of agreement plus or minus 0.75 D. The mean difference between non-cycloplegic and cycloplegic cylinder values measured by Retinomax reached 0.17 D and was statistically significant. Manifest thresholds of ≥1.5 D, ≥1.75 D, ≥2 D cylinder value diagnosed 2 D of astigmatism under cycloplegia respectively with 71–84%, 59–80%, 51–54% of sensitivity (right eye-left eye) and 90–92%, 95%, 98% of specificity.

Conclusion—Without cycloplegia, Retinomax is able to measure cylinder power with the same reproducibility as cycloplegic retinoscopy. No significant difference was found in the cylinder values obtained with the quick and the normal modes. Therefore, the quick mode of measurement is recommended as it is more feasible in children. No difference, which is significant from a screening point of view, exists between the non-cycloplegic and the cycloplegic cylinder value (<0.25 D). Retinomax diagnoses abnormal astigmatism (≥2 D) in a non-cycloplegic refractive screening at preschool ages with 51–84% sensitivity rates and 98–90% specificity rates, depending on the chosen threshold of manifest astigmatism. If 2 D of manifest astigmatism is chosen as a positive test, the positive predictive value of the screening reaches 81–84% and the negative predictive value 91–90% (right eye-left eye).
As we are involved in a non-cycloplegic refractive screening with the hand held refractor Retinomax, we wanted to test the reliability and accuracy of this refractor. We have already studied its ability to screen for high hyperopia and decided to further investigate its usefulness in screening for astigmatism.

**Material**

**RETINOMAX HAND HELD REFRACTOR**

This hand held refractor has been fully described elsewhere. In the normal mode, a fogging system aims to minimise accommodation. The quick mode disables the fogging system and speeds the measurement process which is helpful in very young children: only 10 seconds are needed to start measuring and obtain 16 data points for both eyes. It also allows easy repetition of measurements.

The width of the target (christmas tree on a green grass and blue sky background) is 2 cm, the subject eye is situated 6 cm away from the target. If the subject does not look at the christmas tree but at either side of the target, this will induce a disparity of approximately 10° between the fixation axis and the axis of autorefration. According to Banks, this could induce a spurious astigmatism of 0.75 to 1.5 D in children.

**Subjects and methods**

Since November 1995, we have organised free visual screening for children between 9 to 36 months at our university hospital situated in Brussels. Specifications concerning the screening have been described elsewhere. Among other tests, this visual screening required a measurement of manifest refraction with the Retinomax autorefractometer. If the child was reluctant and had to be forcibly steadied, care was taken not to push on his eye when opening the lids during the measurements to avoid artefactual astigmatism. In our tests, the success rate of measuring refraction with the hand held refractor in children of this age reached 98.5%. The 1.5% of children who could not be successfully refracted with the Retinomax were refracted by another method (Viva o axis binocular videorefraction, Tomey Inc) and were not included in this study.

Among the 1205 screened children, 20% were screened positive because they had one or more criteria of abnormal manifest refraction (hyperopia >1.5 D, myopia >3 D, astigmatism >2 D, anisometropia >1.5 D) and/or a squint. These children were referred to an ophthalmologist outside the hospital (for deontological reasons, given the fact that the screening was free, no child attending the screening could be referred to an ophthalmologist appointed by the hospital). Before starting the screening, we established a list of ophthalmologists who were interested in treating children (61 ophthalmologists in Brussels area). If a child was screened positive, we gave this list to the parents, together with the result of the screening specifying the presence or absence of any squint, media opacity, or refractive anomaly. In case of a refractive defect, the manifest refraction measured by the Retinomax was stated. The consulting ophthalmologist was asked to return to us a dated and signed feedback form specifying the cycloplegic refraction of the child and confirming the presence or absence of any squint or media opacity.

In our screening, the retained refractive value of one measurement corresponded to the isolated representative value of the eight collected data points for each eye, expressed in sphere, negative cylinder, and axis.

The use of normal or quick mode of Retinomax measurement was registered.

In a total of 1205 screened children, 906 children had one measurement only, 275 had two measurements, and 24 had three measurements without cycloplegia. Repeated measurements were taken during the same session and were performed by one of the authors (MC) or by the orthoptist in charge of the screening. We did not compare the results from different operators as the training and competence needed for using Retinomax is minimal.

We analysed the reproducibility between non-cycloplegic measurements applying the method described by Bland and Altman: in the 299 cases with two measurements or more, we determined the mean difference between them and the 95% limits of agreement of the three refractive components.

In order to establish whether the quick mode influences the measurement of astigmatism, we compared both modes of measurement without cycloplegia in 93 children.

Out of the 1205 children, 302 were also refracted with cycloplegia (three drops of cyclopentolate 0.5% in each eye at 5 minute intervals followed by measurement 40 minute later) during the same session, by the same operators as previously described, using the same hand held refractometer. These 302 children were selected on the sole criterion that the parents agreed to cycloplegia being performed. If the child was screened positive, the parents were told: “We suspect a visual defect in your child, do you agree if we confirm this defect by a further investigation that requires drops in the eyes of your child.” If the child was screened negative, the parents were told “The visual screening does not show any defect in your child, and this can be double checked by a further investigation with drops if you wish.”

Forty three per cent of these 302 children were screened positive because they had one or more criteria of abnormal manifest refraction (hyperopia >1.5 D, myopia >3 D, astigmatism >2 D, anisometropia >1.5 D) and/or a squint. The other 57% were screened negative.

We performed the analysis of agreement between the 302 non-cycloplegic and cycloplegic cylinder values measured by Retinomax.

Whenever non-cycloplegic measurements had been repeated, we chose the most positive representative value for the sphere and the least negative for the cylinder, in order to minimise accommodation.

Eighty eight (7%) of these 1205 screened children had a cycloplegic refraction performed by an on table autorefractor (78 children) or by retinoscopy (10 children): they
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![Graphs and Tables]

The figures and tables presented in the document illustrate the agreement between non-cycloplegic and cycloplegic Retinomax cylinder power values. The graphs show age distribution and proportion of children in different age groups. Tables 1 and 2 detail the reproducibility of non-cycloplegic Retinomax measurements and the agreement between non-cycloplegic and normal mode Retinomax values, respectively.

The text discusses the results of the study, emphasizing the importance of screening for refractive errors in children. It highlights the challenges in obtaining comprehensive feedback forms and the selection bias in the population screened. The predictive values of the screening are calculated for different thresholds of manifest astigmatism under cycloplegia. The document concludes with a discussion on the implications of the findings and the need for further research to improve screening methods.

The predictive values of our refractive screening were calculated for three different thresholds of manifest astigmatism (≥1.5, ≥1.75, and ≥2 D) considering as a true positive case an astigmatism ≥2 D under cycloplegia. These predictive values were estimated in the 302 cases having cycloplegic refraction measured by Retinomax and in the 88 cases having cycloplegic refraction performed by retinoscopy or an on table refractor.

**Results**

Figure 1 shows the age distribution in months of the 1205 screened children, of the 302 children refracted under cyclopia by the hand held refractor, and of the 88 children refracted under cycloplegia by retinoscopy or on table refractor.

Table 1 shows the mean difference of non-cycloplegic minus cycloplegic value. **S** = significant.

### Table 1: Reproducibility of non-cycloplegic Retinomax measurements

<table>
<thead>
<tr>
<th>Sphere (D)</th>
<th>Cylinder (D)</th>
<th>Axis (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right eye</td>
<td>Left eye</td>
</tr>
<tr>
<td>Number of pairs</td>
<td>302</td>
<td>302</td>
</tr>
<tr>
<td>d</td>
<td>0.16</td>
<td>0.19</td>
</tr>
<tr>
<td>95% lim agreement</td>
<td>d = −1.23 d = −1.22</td>
<td></td>
</tr>
<tr>
<td>p (paired t test)</td>
<td>S</td>
<td>S</td>
</tr>
</tbody>
</table>

**d** = mean difference between repeated values of hand held refractor. **NS** = not significant.

### Table 2: Agreement between non-cycloplegic quick and normal mode Retinomax values

<table>
<thead>
<tr>
<th>Sphere (D)</th>
<th>Cylinder (D)</th>
<th>Axis (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right eye</td>
<td>Left eye</td>
</tr>
<tr>
<td>Number of pairs</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>d</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>95% lim agreement</td>
<td>d = −1.23 d = −1.22</td>
<td></td>
</tr>
<tr>
<td>p (paired t test)</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

**d** = mean difference of quick mode value minus normal mode value. **NS** = not significant.

The discussion section emphasizes the importance of screening for refractive errors, particularly among children with a family history of strabismus or amblyopia. The authors suggest that further research is needed to refine screening methods and improve the accuracy of diagnostic tools.
Table 4  Performances of the non-cycloplegic screening for three di
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manner than ±1 D. This is comparable with the agree-
ment between repeated measurements along one
meridian by non-cycloplegic autorefract-
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\(-0.72\) to 0.71 D) and by cycloplegic
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ypo measurements in the quick and normal
tes. Wood et al \(^1\)
found d ±20° with the
meas-
urements in this mode are much easier to
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n
v
\(0.17\) D is, however, not clinically
a highly specific test to avoid overreferrals and
mographic data gives a positive predictive value.18

The relative proportion of positive (43%) and negative (57%)
results among the 302 children controlled under cycloplegia is
different from the one of the screening (20% versus
spherical in nature but may include
v
\(+0.75\) D. This
\(12\)
below 1 D.17 We chose therefore a value of 2 D
as astigmatism with coincident axes is
v
\(+1.75\) D and
v
\(+1.5\) D
r
\(+0.75\) D. This
\(+0.75\) D. This
r
\(+1.75\) D
\(+1.75\) D
\(+1.75\) D
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\(12\)
0.17 D and is
v
\(+1.75\) D
\(+1.75\) D
\(+1.75\) D
\(+1.75\) D

The comparison of non-cycloplegic measure-
ments in the quick and normal mode give
similar results: no significant difference and
95% limits of agreement around ±0.75 D. This
confirms our previous study2 concerning the
amount of sphere in hyperopic children: no
difference is seen between the quick and the
normal modes in minimising accommodation.
We therefore suggest choosing the quick mode
for screening children of this age, since
measurements in this mode are much easier to
obtain and nearly always successful in our test.

The mean difference between non-
cycloplegic and cycloplegic cylinder values
measured by Retinomax reaches 0.17 D and is
statistically significant. This means that the
value of the cycloplegic cylinder is generally
higher than the non-cycloplegic one (all our
cylinders are negative). As already suggested
by Rubin and Harris,16 this could imply that
the accommodative change in a human eye is
not entirely spherical in nature but may include
an additional cylindrical component. This
difference of 0.17 D is, however, not clinically
important from a screening point of view.

Several concerned ophthalmologists do not
prescribe glasses in children of 12 months of
age if an astigmatism with coincident axes is
below 2 D.12 We chose therefore a value of 2 D
or more of astigmatism under cycloplegic con-
tion as true positive case to establish the sen-
sitivity, specificity, and predictive values of the
screening.

In our opinion, Table 4 gives a more
accurate idea of the overall sensitivity and spe-
cificity rates of our screening than Table 5: the
sample is larger (302 children versus 88), the
age distribution is comparable with the one of
the screened population (Fig 1), and the
refraction is better controlled (all measure-
ments were made the same day, by the same
operators, with the same refractor, and using
the same cycloplegic protocol). The results of
both tables are however rather similar. The
threshold of manifest astigmatism ≥2 D gives
the best figures regarding specificity and
positive predictive value. The thresholds of
≥1.75 D and ≥1.5 D give a better combina-
tion of sensitivity and specificity.

Although a high threshold of abnormal
astigmatism diminishes the sensitivity of the
screening, it improves its specificity. To validate
our visual screening and as astigmatism is not a
severely disabling eye condition, we preferred
a highly specific test to avoid overreferrals and
to have a good positive predictive value.18
Therefore, we decided to keep the threshold of 2 D for the ongoing screening.

To conclude, manifest refractive screening with Retinomax diagnoses abnormal astigmatism (>2 D) with 51% to 84% sensitivity rates and 98% to 90% specificity rates, depending on the chosen threshold of manifest astigmatism. If 2 D of manifest astigmatism is considered for positive test, the positive predictive value of the screening reaches 81–84% and the negative predictive value 91–90% (right eye-left eye). As the quick mode of measurement is more feasible in children and as we did not establish any significant difference between the quick mode and the normal mode in measuring manifest refraction, we also suggest choosing this mode of measurement for screening very young children.

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