The accuracy of non-cycloplegic auto refractor versus retinoscopy in a pediatric population

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Abstract
Purpose: Auto refractor and retinoscopy are both routinely utilized objective refractive techniques for pediatric vision care. There are certain clinical settings for which cycloplegia is not feasible such as vision screenings and humanitarian eye care clinics. The purpose of this project was to determine the accuracy of the auto refractor compared to retinoscopy under non-cycloplegic conditions, such as occur in vision screenings and triage-level eye care clinics.

Methods: Seventy-five children were included in the study. Each child had auto refractor and retinoscopy performed on both eyes prior to instillation of 1 drop of 1% Tropicamide. After 20 minutes, auto refractor and retinoscopy were performed again for comparison. Cycloplegic retinoscopy was the standard to which all findings were compared.

Results: Of the 75 right eyes measured by the auto refractor prior to cycloplegia (NCAR), the average finding was 1.35D more minus than the standard, cycloplegic retinoscopy (CR). NCAR on the 75 left eyes were 1.15D more minus than CR. When non-cycloplegic retinoscopy (NCR) was performed on the same 75 right eyes, they were found to be only 0.47D more minus than CR, while the 75 left eyes were found to be only 0.25D more minus. The case specific range of discrepancy from CR values was up to 6.00D for NCAR and up to 2.50D for NCR. Cycloplegic auto refractor (CAR) results showed the right eye to be only 0.20D more minus, and the left eye CAR results were 0.28D more plus than CR. Comparison between CAR and CR showed no significant difference between means.

Conclusions: This study illustrates that non-cycloplegic auto refraction is not an accurate refractive measure in children due to poor accommodative control. Distance retinoscopy performed with appropriate fogging technique is the most accurate objective measure to prescribe from in the vast majority of cases.

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The Accuracy of Non-cycloplegic Auto refractor versus Retinoscopy in a Pediatric Population

By

Ronda Olson
Amy Joachim

A thesis submitted to the faculty of the
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Advisor: J.P. Lowery, O.D., M.Ed.
Ronda Olson

Amy Joachim

J.P. Lowery, O.D., M.Ed.
The Accuracy of Non-cycloplegic Auto refractor versus Retinoscopy in a Pediatric Population
Amy Joachim, B.S., Ronda Olson, B.A., John P. Lowery O.D., M.Ed. Pacific University College of Optometry

Purpose: Auto refractor and retinoscopy are both routinely utilized objective refractive techniques for pediatric vision care. There are certain clinical settings for which cycloplegia is not feasible such as vision screenings and humanitarian eye care clinics. The purpose of this project was to determine the accuracy of the auto refractor compared to retinoscopy under non-cycloplegic conditions, such as occur in vision screenings and triage-level eye care clinics.

Methods: Seventy-five children were included in the study. Each child had auto refractor and retinoscopy performed on both eyes prior to instillation of 1 drop of 1% Tropicamide. After 20 minutes, auto refractor and retinoscopy were performed again for comparison. Cycloplegic retinoscopy was the standard to which all findings were compared.

Results: Of the 75 right eyes measured by the auto refractor prior to cycloplegia (NCAR), the average finding was 1.35D more minus than the standard, cycloplegic retinoscopy (CR). NCAR on the 75 left eyes were 1.15D more minus than CR. When non-cycloplegic retinoscopy (NCR) was performed on the same 75 right eyes, they were found to be only 0.47D more minus than CR, while the 75 left eyes were found to be only 0.25D more minus. The case specific range of discrepancy from CR values was up to 6.00D for NCAR and up to 2.50D for NCR. Cycloplegic auto refractor (CAR) results showed the right eye to be only 0.20D more minus, and the left eye CAR results were 0.28D more plus than CR. Comparison between CAR and CR showed no significant difference between means.

Conclusions: This study illustrates that non-cycloplegic auto refraction is not an accurate refractive measure in children due to poor accommodative control. Distance retinoscopy performed with appropriate fogging technique is the most accurate objective measure to prescribe from in the vast majority of cases.
Acknowledgments

We would like to thank Dr. Lowery for all of his guidance and support. Without his help, this project would not have been possible. Also we would like to thank the Oregon Lions Club for their financial support. Many Lion’s members were present in San Blas, Mexico and helped us to gather all of our data. Third, we must thank all of our fellow Amigos members who went on the trip with us. They helped us obtain all of our data, and without them, none of this would have been possible.
Vision screenings include a battery of tests to diagnose the health and refractive error of the pediatric population. A primary goal is to detect any uncorrected refractive error that could lead to amblyopia. Methods for determining refractive error in children include retinoscopy and auto refraction. Under cyclopleged conditions, both of these methods are more accurate because accommodation is inhibited. This prevents gross underestimation of hyperopia. Due to time and legal constraints cycloplegia is not usually performed during a vision screening. Autorefaction is often chosen over retinoscopy to determine refractive error in the screening setting due to its speed and minimal difficulty. Autorefraction is also used in many humanitarian eye care clinics in which prescription lenses are dispensed. However, clinical research has shown discrepancies in the reliability of the auto refractor in the pediatric population under non-cycloplegic conditions.

The aim of this study was to determine the most accurate method for determining refractive error in the pediatric population when cycloplegia is not possible. There is minimal data supporting whether or not there is a significant clinical difference in non-cycloplegic autorefractor (NCAR) and non-cycloplegic retinoscopy (NCR). There are many studies that compared NCAR to cycloplegic autorefractor (CAR), and many studies which compared NCR to cycloplegic retinoscopy (CR), but we found none that measured both NCAR and NCR within subjects with a cycloplegic control value for comparison.

Clinical research has clearly shown many times that autorefractor is not a reliable means of determining refractive error in children under non-cycloplegic conditions.\textsuperscript{1,3-5} In studies comparing NCAR to CAR, it was shown the NCAR tends to underestimate hyperopia and measurement reliability varied greatly from one child to the next. NCAR
results differed from CAR results by more than 1.00D in many cases.\textsuperscript{3,4} This inaccuracy can be clinically significant for a young child. These studies have shown that without cycloplegia, autorefractor can be very unreliable for determining refractive error due to children’s accommodation.\textsuperscript{1,3-5}

Retinoscopy may still give results which show some of these induced myopia effects, but the dioptric amount is less, and the results more reliable. The difference between NCR and CR has been found to be proportional to the amount of hyperopia.\textsuperscript{7} It is also rare for the difference between NCR and CR to differ by more than 2.00D.\textsuperscript{6,7}

The basis of the study was to find the most accurate and repeatable method for determining refractive error in the pediatric population when cycloplegia cannot be performed, NCAR or NCR. This study will provide support to the most clinically accurate method.

Methods

Seventy-five subjects, 46 girls and 29 boys, ages 4 to 13 (mean age 8.73) participated in the study. The study was performed in San Blas, Mexico, as part of an Amigos Eye Care Children’s vision screening, and all of the participants were of Hispanic decent. The clinic was administered through the local school district. Parents were informed of the free vision exams which would include the use of cycloplegic drops. All subjects had normal ocular health with no strabismus. The average spherical equivalent was determined by cycloplegic retinoscopy, as it is often termed the gold standard in determining refractive error. Cycloplegic retinoscopy values were then compared to all other findings. In situations where the cycloplegic retinoscopy and cycloplegic auto refraction differed by more than 1.00D, the two values were averaged to
compensate for any possible doctor error. This only needed to be done on 12 of the 150
eyes examined.

The auto refractor used in this study was the Retinomax. The cycloplegic drop
used in this study was tropicamide 1%. Tropicamide was used in this study instead of
cyclopentolate due to the decreased number of central nervous system side effects and
because of its shorter duration of cycloplegia. In studies done by Twelker et. al. on
children ages 4-7 months, and Egashira et. al. on children ages 6-12 years, tropicamide
1% was shown to be as effective in determining distance refractive error as
cyclopentolate 1% when the measures were taken between 20 to 30 minutes after drop
installation.

Each child had non cycloplegic auto refraction (NCAR) and non cycloplegic
retinoscopy (NCR) performed on both eyes prior to installation of 1 drop proparacaine
0.5%, and 2 drops of tropicamide 1%. After 20 minutes, each child had cycloplegic auto
refraction (CAR) and cycloplegic retinoscopy (CR) performed again for comparison.
The doctors performing retinoscopy were not permitted to see any of the autorefractor
values to prevent any bias in the findings.

Results:

Spherical equivalents were calculated for each measured refraction on all eyes to
yield four comparison values. The four comparison values were Non-cycloplegic
retinoscopy (NCR), Non-cycloplegic autorefraction (NCAR), Cycloplegic retinoscopy
(CR), and Cycloplegic autorefraction (CAR). Cycloplegic retinoscopy was used as the
gold standard to determine accuracy of the other methods. The mean spherical equivalent
of the 75 right eyes examined with CR was +1.32D, and the mean spherical equivalent of
the 75 left eyes examined with CR was +1.29D. The range of all values went from +10.00D to -7.25D. The astigmatism range for all eyes went up to 4.25D with 13% greater than 1.00D.

Non-cycloplegic results

NCAR was shown to be 1.35D more minus OD and 1.15D more minus OS than CR.

NCR, however, was shown to be only 0.47D more minus OD and 0.25D more minus OS. The range of difference for NCAR went up to 6.63D more minus, while NCR’s range went up to only 2.50D more minus. There was also a significant difference found when comparing NCAR and NCR to CR. NCAR differed from CR by more than 1.00D in 57% of the right and left eyes. NCR only differed by 1.00D in 17% of the right eyes and 6.60% of the left eyes. Dry values were also compared to CAR with similar results being found. There was a strong correlation between CAR and CR with the mean difference in spherical equivalents being 0.19D OD, and 0.28D OS. The cylinder component of CAR was very comparable to those values obtained by CR.

Data Summary: Dry measures compared to Wet Retinoscopy and Wet AR

<table>
<thead>
<tr>
<th>Dry Values vs Wet Ret</th>
<th>Mean Difference in Spherical Equivalent</th>
<th>High</th>
<th>Low</th>
<th>R</th>
<th>% differing by more than 1 D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRY - WET</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AutoRx OD</td>
<td>-1.35</td>
<td>1.125</td>
<td>-6.63</td>
<td>0.85</td>
<td>57%</td>
</tr>
<tr>
<td>AutoRx OS</td>
<td>-1.15</td>
<td>1.625</td>
<td>-4</td>
<td>0.93</td>
<td>57%</td>
</tr>
<tr>
<td>Ret OD</td>
<td>-0.47</td>
<td>1.25</td>
<td>-2.5</td>
<td>0.95</td>
<td>17%</td>
</tr>
<tr>
<td>Ret OS</td>
<td>-0.25</td>
<td>0.875</td>
<td>-2.5</td>
<td>0.96</td>
<td>6.60%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dry Values vs Wet Auto</th>
<th>Mean Difference in Spherical Equivalent</th>
<th>High</th>
<th>Low</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRY - WET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AutoRx OD</td>
<td>-1.15</td>
<td>0.75</td>
<td>-5.88</td>
<td>0.87</td>
</tr>
<tr>
<td>AutoRx OS</td>
<td>-0.86</td>
<td>0.5</td>
<td>-3.13</td>
<td>0.95</td>
</tr>
<tr>
<td>Ret OD</td>
<td>-0.27</td>
<td>1.875</td>
<td>-2.88</td>
<td>0.9</td>
</tr>
<tr>
<td>Ret OS</td>
<td>0.03</td>
<td>3</td>
<td>-2.75</td>
<td>0.94</td>
</tr>
</tbody>
</table>
Correlation of Cycloplegic Measures

<table>
<thead>
<tr>
<th>Wet Ret vs Wet AutoRx</th>
<th>Mean Difference in Spherical Equivalent</th>
<th>High</th>
<th>Low</th>
<th>R</th>
<th>% differing by more than 1 D</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD</td>
<td>0.19</td>
<td>2.375</td>
<td>-1.38</td>
<td>0.96</td>
<td>8%</td>
</tr>
<tr>
<td>OS</td>
<td>-0.28</td>
<td>1.625</td>
<td>-3</td>
<td>0.96</td>
<td>12%</td>
</tr>
</tbody>
</table>

Cylinder Power Measures: Wet AR vs Wet Ret

<table>
<thead>
<tr>
<th>Cylinder Power OD</th>
<th>Mean diff. AR - Ret = -0.23</th>
<th>1</th>
<th>-3</th>
<th>0.8</th>
<th>4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder Power OS</td>
<td>Mean diff. AR - Ret = -0.23</td>
<td>2.25</td>
<td>-3.25</td>
<td>0.85</td>
<td>4%</td>
</tr>
</tbody>
</table>

Discussion:

The results obtained using NCAR and NCR produced very different values, questioning the reliability of NCAR in a pediatric population. The values were considered clinically significant if they varied by more than 1.00D and this occurred 57% of the time with NCAR. While it is always of great concern when the prescription differs from the actual by more than 1.00D, it is especially harmful in a young child who is only a 1.00D hyperope, but is read by the autorefractor as a 1.50D myope. The autorefractor produces a myopia effect which results in over-minus refractions in children. This large of a difference is not acceptable in children, who depend on vision for the majority of their learning.

Many other studies have demonstrated the myopic effect induced by the autorefractor, but they have not compared these results to retinoscopy in order to determine which would have been the most appropriate method to prescribe lenses from.
when cycloplegia is not possible. Harvey, et al. demonstrated in a study done on children ages 3.6 thru 5.6 that NCAR, using a Nikon Retinomax, was 1.15D more minus on average than CAR. They concluded NCAR over-estimated myopia, and measurement accuracy varied greatly between children. Evans also compared NCAR to CAR in a pediatric population. This study showed NCAR, with the R x 1 autorefractor, to be less consistent and on average 1.15D more minus than CAR. Helveston, et al. examined 96 children and found the Nidek 30000 autorefractor was much more reliable when a cycloplegic agent was used and accommodation limited. This study found NCAR to induce 8.00D of myopia in some cases which is even greater than our result of 6.63D induced myopia. Our results showed NCAR with the Retinomax to be 1.15D OD and 0.86D OS more minus than the findings obtained with CAR. In hyperopes greater than 2.00D, the mean difference between NCAR and CAR was -1.53, in hyperopes less than 2.00D the mean difference was also -1.53, and in myopes the mean difference was -0.0011. Some children were over-minused by up to 5.88D.

Autorefraction can be a very useful tool to the optometrist in certain situations. In others, however, using the autorefractor can and will do more harm than good. Autorefraction should only be performed on children when cycloplegia is possible or to refine the cylinder axis and power. One such study that demonstrated this fact is the El-Defrawy et al. study which included 102 children, ranging in age from 5 months to 6 years. NCAR and CAR, along with CR, were performed. Results obtained with CAR and CR were not significantly different in the age range for sphere and cylinder findings. The results of the NCAR were extremely inaccurate and overestimated myopia by up to 8.00D. Autorefractor did not show any tendency to consistently over or under-estimate
the refractive error when cycloplegic drops were used. Our findings also showed the CAR and CR to be very consistent. The values had a mean difference in spherical equivalents of 0.19 and -0.28, OD and OS respectively.

Non-cycloplegic retinoscopy, with appropriate fogging technique, provides a more reliable predictive measure of cycloplegic findings. Young et al. performed a study comparing NCR to CR with 328 subjects ranging from 6 to 15 years old. Ninety-one of the eyes were myopic, 206 eyes had refractive error of plano to 3.00D of hyperopia, and 31 eyes had hyperopia greater than 3.00D. The mean difference between CR and NCR was from +0.38D to -0.13D for the myopic eyes, +0.67D for the low hyperopes, and +2.06D for the moderate to high hyperopes. They concluded that it is unlikely for the difference between CR and NCR to exceed +2.00D. Our results for NCR and CR showed a mean difference of +0.64 for hyperopes greater than 2.00D, +0.51 for hyperopes less than 2.00D, and -0.125 for myopes. Another similar study was performed by Hiatt. Retinoscopy, before and after cycloplegia, was performed on 149 hyperopic eyes of patients aged 6.0 to 10.0 years. It was concluded that from 25% to 33% more hyperopia is measured after cycloplegia, with a more pronounced difference in the younger patient. There was a correlation between the amount of original hyperopia and that found by CR. Greater amount of refractive error resulted in a greater difference between the two measurements.

When cycloplegia is not possible, such as in eye care missions or vision screenings, distance retinoscopy, with appropriate fogging, provides the most clinically acceptable prescriptive measures. Retinoscopy allows the doctor to monitor the child’s
focus and to reduce the amount of induced myopia. The mean error found in NCAR is
not acceptable for prescribing lenses to children.

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