# Comparison of Accuracy in Measuring Refractive Error by Ophthalmology Residents Between Classical and Innovative Teaching Techniques

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## ABSTRACT

**Objective:** To compare the accuracy of measuring refractive error by retinoscopy between classical and innovative teaching techniques.
**Methods:** Thirty ophthalmic residents with best-corrected visual acuity not less than 6/9, and no color blindness were included. The first test was conducted (for all participants) by a randomized blinded practice with a five different refractive error schematic eyes for 15 minutes. After the first test, all of them were taught and practiced with the retinoscopy simulator. The second test was undergone with the same five schematic eyes but in different order for 15 minutes. The answers of the second test were recorded.
**Results:** Seven were male and 23 were female with the mean age of 28.7 year-old. There were 10 participants in each group with less than 1 year, 1 year and 2 years experience of retinoscopy training. We found no statistical difference in the total correction score of all 3 groups before and after using retinoscopy simulator (p= 0.668). Only the group with less than 1 year of experience had a significant improvement in total correction score (p= 0.015) after using the retinoscopy simulator.
**Conclusion:** Retinoscopy simulator can help the beginner to recognize and become familiar with the reflexes observed from retinoscopy, but it is not effective to be an alternative technique for the classical retinoscopy teaching method.

**Keyword:** Retinoscopy simulator

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## INTRODUCTION

Retinoscopy is a classical objective method of measuring the refractive error of an eye by observing the light that is reflected from the retina. Various reflexes and the reflex movements have to be neutralized to find the refractive error of the eye. We teach about the appearance of these reflexes by explanation via a schematic eye. The new refractionists have to imagine and learn by their experience. Many devices were invented to demonstrate the dynamics of these reflexes to a second observer.[1-4] Because of the difficulty in demonstrating the actual retinoscopic reflex to a second observer both for teaching and research, there were efforts to try to illustrate these reflexes with a highly sensitive television camera and an image processor[1] or a special device that attached to the retinoscope.[2] Emery K, et al[3] introduced a rubber model eye which simulated a variety of refractive states and a video camera system to capture the reflex and present it on a video monitor. Until for the recent year, a computer-based program and computer animation were used for the better understanding of retinoscopy.[4] In this study, we used a computer-based program called "retinoscopy simulator" from Alcon Institute website[5] (Fig 1). The authors allow users to use this program for free for academic and/or research purposes. Furthermore this website can be used as a standalone program that the users can download the program and practice without any on-line service needed. The simulator can demonstrate various reflexes which can be detected from a retinoscope. The users can set any kind of refractive errors including myopia, hyperopia and astigmatism with every degree of astigmatism to see how the reflex looks like in each setting. Furthermore the users can use a computer set up program for an unknown refractive error as a self test.

We used this simulator to teach ophthalmic residents to see if it can help improve their ability in refraction. The study was done to compare the accuracy of measuring refractive error by retinoscopy between classical and this innovative teaching technique.

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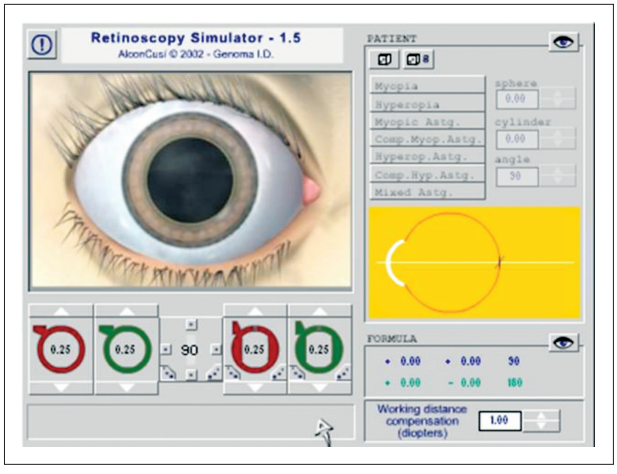


**Fig 1.** Retinoscopy simulator.
(Alcon Institute [Internet]. Retinoscopy Simulator. [Cited 2012 Mar 15]. Available from: http://www.institutoalcon.com/nvisor.asp?LNG=ENG&UID=5081&TYPE=4)

## MATERIALS AND METHODS

Ophthalmic residents with the age of 18 years old or older and who had best-corrected visual acuity not less than 6/9 and no color blindness were included in this study. They all provided written consent before the study enrollment. The study was approved by the Siriraj Institutional Review Board (SIRB). Demographic data (i.e, age, sex and refractive error) and number of years of experience in retinoscopy were recorded. For the participants who had less than 1 year of retinoscopy experience they had a classical retinoscopy teaching before the test. Classical retinoscopy teaching means that the reflexes and reflex movements reflected from the eye by a retinoscope were demonstrated by explanation via a schematic eye. Then all participants underwent a 15-minute test with 5 unknown schematic eyes that were set up with a different refractive error including low myopia (-4.25 diopters (D)), low hyperopia (+4.50D), high hyperopia (+11.00D), compound hyperopic astigmatism (+6.00-1.25x180) and compound myopic astigmatism at oblique axis (-0.75-3.00x45). The tests were arranged in order of refractive error as previously mentioned. The answers of the first test were recorded. After the first test, all of them were taught how to use the retinoscopy simulator and they practiced by themselves for 2-3 weeks. Everyone was asked about practicing. The second test was undergone only after the participant had already practiced with the simulator. The same 5 schematic eyes were used to test but in the different order (the order of the test was the same in every participant) for 15 minutes. At this time, the first test was compound hyperopic astigmatism followed by low hyperopia, low myopia, high hyperopia and compound myopic astigmatism at oblique axis as the fifth test. The answers of the second test were recorded. For the correct answer of both tests, the spherical power and astigmatic power errors should not more than 0.5 D and the axis of astigmatism error should not be more than 10 degrees. Total correction score (number of correct answers) were compared between the first and the second test.

All statistical analyses were performed using PASW statistics 18.0 (SPSS Inc., Chicago, IL, USA). Numbers and percentages were described for categorical variables, whereas continuous variables were summarized by mean and standard deviation or median and range as appropriate. Categorical variables were compared using Chi-square test. Mann-Whitney U test was performed to compare continuous data between two groups. Wilcoxon signed ranks test was used to compare continuous variables before and after using the retinoscopy simulator. Kruskal-Wallis test was used to compare continuous variables among the three groups. All tests of significance were two tailed with p value <0.05.

## RESULTS

Thirty participants were enrolled in this study. The mean age of the participants was 28.7 ± 0.9 years old (range 26.72 to 30.63 years). Seven (23.3%) were male and 23 (76.7%) were female. The median of spherical equivalent was -1.81D in the right eye (maximum -7.88D, minimum +0.50D) and -2.06D in the left eye (maximum -8.25D, minimum +0.38D). There were 10 participants in each group according to the number of years of experience in retinoscopy including less than 1 year, 1 year and 2 years. All of the participants that had less than 1 year experience in retinoscopy (group 1) were the first year residents (10), all of the participants that had 1 year experience (group 2) were the second year residents (10) and all of the participants that had 2 years of experience (group 3) were the third year residents (10). Therefore, we defined group 1 as the first year residents, group 2 as the second year residents and group 3 as the third year residents. All of the participants with significant refractive error were corrected before doing the test.

The correct answers in each group were compared before and after using the retinoscopy simulator according to the refractive error setting (Table 1-5). The missing numbers were the numbers of the participants who did not

**TABLE 1.** Comparison among 3 groups of correct answers of before and after using retinoscopy sumulator in the each test.

| Using retinoscopy simulator | Test | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High hyperopia | | | *p-value*[a] | Low myopia | | | *p-value*[a] | Compound myopic astigmatism at oblique axis | | | *p-value*[a] |
| Group | 1 | 2 | 3 | | 1 | 2 | 3 | | 1 | 2 | 3 | |
| Before | | | | | | | | | | | | |
| Number of answer (n) | 9 | 10 | 8 | 0.278 | 10 | 10 | 10 | 0.034* | 6 | 10 | 8 | 0.732 |
| Number of correct answer (%) | 3 (33.3) | 1 (10.0) | 2 (25.0) | | 0 (0) | 2 (20.0) | 8 (80.0) | | 1 (16.7) | 2 (20.0) | 3 (37.5) | |
| After | | | | | | | | | | | | |
| Number of answer (n) | 4 | 9 | 10 | 0.277 | 10 | 10 | 10 | 0.648 | 5 | 10 | 9 | 0.558 |
| Number of correct answer (%) | 0 (0) | 1 (11.1) | 0 (0) | | 4 (40.0) | 3 (30.0) | 4 (40.0) | | 1 (20.0) | 1 (10.0) | 2 (22.2) | |

[a]Chi-square test
*Significant at 0.05 level

**TABLE 1.** Comparison among 3 groups of correct answers of before and after using retinoscopy sumulator in the each test (continue).

| Using retinoscopy simulator | Group | Test Compound hyperopic astigmatism 1 | 2 | 3 | *p-value*[a] | Low hyperopia 1 | 2 | 3 | *p-value*[a] |
|---|---|---|---|---|---|---|---|---|---|
| Before | | | | | | | | | |
| Number of answer (n) | | 9 | 9 | 10 | 0.651 | 4 | 7 | 9 | 0.856 |
| Number of correct answer (%) | | 0 (0) | 0 (0) | 1 (10.0) | | 3 (75.0) | 5 (71.4) | 6 (66.7) | |
| After | | | | | | | | | |
| Number of answer (n) | | 10 | 10 | 10 | - | 10 | 9 | 10 | 0.26 |
| Number of correct answer (%) | | 0 (0) | 0 (0) | 0 (0) | | 8 (80.0) | 5 (55.6) | 7 (70.0) | |

[a]Chi-square test
*Significant at 0.05 level

**TABLE 2.** Comparison among 3 groups of correct answers of before and after using retinoscopy simulator in the test of low myopia.

| Using retinoscopy simulator | Group 1 | 2 | 3 | *p-value* [a] |
|---|---|---|---|---|
| Before | | | | |
| Number of answer (n) | 10 | 10 | 10 | |
| Number of correct answer (%) | 0 (0) | 2 (20.0) | 8 (80.0) | 0.034* |
| After | | | | |
| Number of answer (n) | 10 | 10 | 10 | |
| Number of correct answer (%) | 4 (40.0) | 3 (30.0) | 4 (40.0) | 0.648 |

[a]Chi-square test.
*Significant at 0.05 level.

**TABLE 3.** Comparison among 3 groups of correct answers of before and after using retinoscopy simulator in the test of compound myopic astigmatism at oblique axis.

| Using retinoscopy simulator | Group 1 | 2 | 3 | *p-value* [a] |
|---|---|---|---|---|
| Before | | | | |
| Number of answer (n) | 6 | 10 | 8 | |
| Number of correct answer (%) | 1 (16.7) | 2 (20.0) | 3 (37.5) | 0.732 |
| After | | | | |
| Number of answer (n) | 5 | 10 | 9 | |
| Number of correct answer (%) | 1 (20.0) | 1 (10.0) | 2 (22.2) | 0.558 |

[a]Chi-square tests

**TABLE 4.** Comparison among 3 groups of correct answers of before and after using retinoscopy simulator in the test of compound hyperopic astigmatism.

| Using retinoscopy simulator | Group 1 | 2 | 3 | *p-value* [a] |
|---|---|---|---|---|
| Before | | | | |
| Number of answer (n) | 9 | 9 | 10 | |
| Number of correct answer (%) | 0 (0) | 0 (0) | 1 (10.0) | 0.651 |
| After | | | | |
| Number of answer (n) | 10 | 10 | 10 | |
| Number of correct answer (%) | 0 (0) | 0 (0) | 0 (0) | - |

[a]Chi-square tests

**TABLE 5.** Comparison among 3 groups of correct answers of before and after using retinoscopy simulator in the test of low hyperopia.

| Using retinoscopy simulator | Group 1 | 2 | 3 | *p-value* [a] |
|---|---|---|---|---|
| Before | | | | |
| Number of answer (n) | 4 | 7 | 9 | |
| Number of correct answer (%) | 3 (75.0) | 5 (71.4) | 6 (66.7) | 0.856 |
| After | | | | |
| Number of answer (n) | 10 | 9 | 10 | |
| Number of correct answer (%) | 8 (80.0) | 5 (55.6) | 7 (70.0) | 0.26 |

[a]Chi-square tests

**TABLE 6.** Comparison among 3 groups of corrected score of before and after using retinoscopy simulator for all tests.

| Using retinoscopy simulator | Corrected score for all tests | | | *p-value*[c] |
|---|---|---|---|---|
| | Group 1 | Group 2 | Group 3 | |
| Before | | | | 0.006** |
| Mean ± SD | 0.8±0.8 | 1.0±0.8 | 2.1±0.9 | |
| Median (min, max) | 1 (0, 2) | 1 (0, 2) | 2 (0, 3) | |
| After | | | | 0.687 |
| Mean ± SD | 1.3±0.5 | 1.0±0.9 | 1.3±0.8 | |
| Median (min, max) | 1 (1, 2) | 1.0 (0, 2) | 1.5 (0, 2) | |

[c]Kruskal-Wallis test
**Significant at 0.01 level

answer the test. Only the schematic eye with low myopia setting had statistically significant difference (p=0.034) in correct answers among each group before practicing by the retinoscopy simulator.

Before practicing with the retinoscopy simulator, the median of corrected score in all 3 groups was 1 (range 0 to 3). Group 1 and group 2 had median of corrected score of 1 (range 0 to 2) and group 3 had median of corrected score of 2 (range 0 to 3). The correction score among these 3 groups were statistically significantly different (p = 0.006) (Table 6). When we used multiple comparison for each group we found the statistically significant difference between group 1 and group 3 was similar to between group 2 and group 3, but not for between group 1 and group 2. After practicing with the retinoscopy simulator, the median of corrected score of all 3 groups was 1 (range 0 to 2). Group 1 had median of corrected score of 1 (range 1 to 2), group 2 had median of corrected score of 1 (range 0 to 2), and group 3 had median of corrected score of 1.5 (range 0 to 2). There was no statistically significant difference of the corrected score among these 3 groups (p=0.687) (Table 6). We found no statistically significant difference in the total correction score for all tests of all 3 groups before and after practicing by retinoscopy simulator (p= 0.668).

The median of error of measuring for each test of all 3 groups was compared before and after using retinoscopy simulator and it was found that only the test of low myopia had significantly less error after using the retinoscopy simulator. We compared the correct answer in the test that had only spherical refractive error and the test that had astigmatic refractive error and found that participants could significantly answer the test that had only spherical refractive error more correctly than the test that had astigmatic refractive error both before and after using the retinoscopy simulator p=0.001 and p<0.001, respectively.

We analyzed the improvement of the correction score for all tests according to the experience year and found that only group 1 that had improvement in total correction score for all tests statistically significant different (p= 0.015) after using the retinoscopy simulator.

Three of the participants had used this retinoscopy simulator program before the test, so we compared the total correction score of this group and the rest of the participants. We found this group had a median total correction score of 2 (minimum 1, maximum 2) and the rest of the participants had a median total correction score of 1 (minimum 0, maximum 3), but there was too difference in numbers in each group so we could not find the difference in statistics.

## DISCUSSION

From our study, the schematic eye with low hyperopia was the test that most of the participants could answer correctly followed by the schematic eye with low myopia, compound myopic astigmatism at oblique axis, high hyperopia and compound hyperopic astigmatism both before and after using retinoscopy simulator. The schematic eye with hyperopia was the test that most of the participants could answer correctly possibly because it is easily recognized with motion reflex, but there was no improvement of total correction score after using the retinoscopy simulator even when this test was moved in order from the fifth test to the second test. There were more participants in group 1 who could answer this test correctly after using the retinoscopy simulator.

For the schematic eye with low myopia, the participants in group 1 could answer this test more correctly after using the retinoscopy simulator. Against motion reflex that was seen in eyes with myopia was more difficult to be recognized than with motion reflex seen in eyes with hyperopia, but it could be recognized more remarkably after practicing with the reflex. Even the difficulty in recognizing against motion reflex, the schematic eye with compound myopic astigmatism was the third test that the participants could answer correctly. The participants in group 3 could answer this test more correctly than the participants in group 1 and 2 before and after using the retinoscopy simulator. In this test, the participants must answer both power and axis correctly, so the experienced participants in group 3 answered more correctly in this test. There was no improvement in this group after using the retinoscopy simulator and many participants did not answer this test.

The schematic eye with high hyperopia was the fourth test that was answered correctly because of the difficulty to recognize the reflex in high refractive error. After we moved this test from the first test to the fourth test, the numbers of the participants that could answer this test were decreased and there was no improvement after using the retinoscopy simulator.

Only a few participants could correctly answer when using the schematic eye with compound hyperopic astigmatism. When we looked at the blind refractive error setting, we found that there was high hyperopia in both axes. That could be the reason why this test was the most difficult test. There was no improvement after using the retinoscopy simulator.

The median error of the answer between before and after practicing with the retinoscopy simulator seemed to be less in almost every test, but only the schematic eye with low myopia was statistically significant (p=0.006) which may be from practicing which made the participants familiar with and could more easily recognize the against motion reflex.

A small number of participants was the limitation of this study because the study wanted to include the participants only in the same semester, so there were only 30 participants for all 3 years of residents.

## CONCLUSION

The reflexes that are seen from doing retinoscopy can tell the refractive error of the patients. The reflex from the eye with high refractive error is the most difficult to recognize. Against motion reflex from the eye with myopia is more difficult to recognize than with motion reflex from the eye with hyperopia. The eyes that had only spherical refractive error are easier to do retinoscopy than the eyes with astigmatic refractive error.

The retinoscopy simulator can help the beginner to recognize and be familiar with the reflexes that will be detected from retinoscopy, though it is not effective to be an alternative technique for the classical retinoscopy teaching method. Only practicing to gain more experience with retinoscopy can help retinoscopists to succeed in refraction with the retinoscope.

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