The Arclight vs. traditional ophthalmoscope

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Published in:
Eye

DOI:
10.1038/s41433-020-0972-3

Publication date:
2020

Document Version
Peer reviewed version

Title: The Arclight vs Traditional Ophthalmoscope: A Cross-over Trial

Running Title: Arclight vs Traditional Ophthalmoscope

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The Authors have no conflicts of interest.

Submission date: April 2020

Abstract

Background/objectives.

To compare skill acquisition of the new, cost-effective Arclight ophthalmoscope, with the traditional ophthalmoscope, in medical students with no prior experience of ophthalmoscopy.

Subjects/Methods.

University of Dundee medical students took part in a cross-over trial. Students were divided into two groups and were alternately taught each device using a video tutorial. In period one, Group A was taught the traditional ophthalmoscope first; Group B was taught the Arclight. They were then assessed using simulated OSCEs, examining four model heads with lettered fundal photographs of varying sizes of font. Groups crossed over following a two-week washout period and were taught the second device and reassessed. A questionnaire was distributed to ascertain students' opinions and preferences.

Results.

Forty medical students participated. Overall, 92.5% of students performed better with the Arclight, irrespective of cross-over trial period.

The mean difference in score in period one of the cross-over trial was 16.77 (95% C.I 11.63 - 21.93), with students performing better with the Arclight ($p < 0.0001$).

The mean difference in score in period two was 8.02 (95% C.I. 4.52 - 11.52), with students performing better with the Arclight ($p < 0.0001$).

Additionally, performance with the traditional ophthalmoscope improved by 52.9% following initial exposure to the Arclight.

The Arclight was the preferred device by 82.5% of students, and 82.5% of students would chose this device for future practice.

Conclusion.

Students performed better with, and preferred the Arclight ophthalmoscope. The Arclight could be considered as a suitable alternative to the traditional ophthalmoscope used for training medical students.

Introduction

Worldwide, ophthalmology is experiencing a reduction in its time allocation within medical school curricula[1], an issue which has been recognised for almost a century[2]. What teaching time is available needs to be utilised effectively, in educating students on the relevant theory, as well as procedural skills of ophthalmology. In the UK currently, ophthalmology training has been cited as not providing medical students with enough training in the skill of direct ophthalmoscopy[3] and in the wider world this is a diminishing, or perhaps absent component of the medical curricula[4]. It has also been suggested that it is perhaps unrealistic to expect students to become competent in direct ophthalmoscopy in the short time frame allotted within UK curricula[5]. Modern ophthalmoscopes are tailored to the skilled specialist, with many features untouched by the inexperienced user,[6] therefore few students are able to use the ophthalmoscope effectively[7].

The direct ophthalmoscopy examination is clearly an important clinical skill, yet the procedure is difficult to teach and equally as problematic to assess[8]. Thus the complexities of ophthalmoscopy are twofold[9]. Not only can the ophthalmoscope be difficult to use correctly, the examiner must also be able to interpret what they see.

Although ophthalmoscopy is challenging at first, success and proficiency can be gained in time[10]. It is a skill all students must be introduced to[11], and that every doctor should be conversant with, not just the trained ophthalmologist[10][12]. The Royal College of Ophthalmologists has produced a curriculum for Undergraduate and Foundation Doctors, and states the undergraduate would be able to:

· "Perform a competent clinical examination of an eye with a pen torch and direct ophthalmoscope.

· Describe the appearance of the optic disc and important retinal landmarks, as well as their orientation and dimensions with ophthalmoscope.

· Demonstrate the red reflex"[13].

Although alternative methods of fundoscopy have been introduced, which allow for the ability to recognise retinal pathology without requiring the skill of ophthalmoscopy[7], they do not allow for examination of the anterior eye. Additionally these devices require the patient to be alert and cooperative, consequently making them irreplaceable by the direct ophthalmoscope in certain conditions, or situations, such as critical care [14].

One alternative to the Traditional Ophthalmoscope (TO) is the Arclight Ophthalmoscope (Arclight Medical, UK, http://arclightscope.com), see images 1 and 2. This is a new, affordable, lightweight ophthalmoscope, which has been created primarily for use in developing countries. Furthermore, UK sales contribute to the provision of devices and education in developing countries [15]. This study explored the possibility that this device could be used as an alternative to the traditional ophthalmoscope as a means for introducing medical students to the technique of ophthalmoscopy, and investigated its effect on skills acquisition.

Materials and methods

Forty University of Dundee medical students took part in a cross-over trial comparing the Arclight to the traditional ophthalmoscope (TO), following approval by the local Research and Ethics Committee. Participants were recruited voluntarily by email, and were included if they were in their first or second year of studies, prior to sitting their ophthalmology placement. They were excluded if they had prior experience with either ophthalmoscope model or of any ophthalmoscopy training. Written consent was obtained from every individual.

The cross-over trial was split into two periods. In period one, twenty-three participants were taught how to use the traditional ophthalmoscope first (Group A), and 17 learned how to use the Arclight ophthalmoscope (Group B). Groups were then assessed on the initial device. There was a two-week washout period between sessions before they were taught the second device. They did not have access to either ophthalmoscope in this period for practice. In period two, Group A (n=23) were then reassessed using the Arclight, and Group B (n=17) were reassessed on the traditional ophthalmoscope. Sessions were randomised based on participant availability and hosted on different days so no conferring could occur. Students were not told which device they would be taught first.

A video tutorial was created to teach students the basics of ophthalmoscopy with each ophthalmoscope, and the different regions of the fundus to assess during the examination.

A normal fundus photograph was “photoshopped” with six different, randomly assigned letters, placed in the key areas of the eye that would be examined when using an ophthalmoscope: superonasal, superotemporal, inferonasal, inferotemporal, optic disc, and macula[10][16]. This image was then made into a slide, which could be placed into a prosthetic eye on a mannequin head, and examined during the ophthalmoscopy procedure.

Two separate sets of fundus slides were created; set one was used when assessing the traditional ophthalmoscope, and set two for the Arclight, reducing the risk of cross-contamination. Each set of slides had four different font sizes, 8pt, 6pt, 4pt and 2pt with distinctive letters on each slide. Both sets used different letters so no conferring or recall could occur. The letters were written in white, capital, Arial bold font, to provide a contrast to the red fundus.

Students were assessed using a mock Objective, Structured, Clinical, Examination (OSCE). Teaching and assessment sessions were consistent, with no bias or influence imposed on the students[17]. The use of the OSCE effectively provided objective assessment of the skill, allowing for comparison between groups[11].

Four mannequin heads were set up in order of largest to smallest fundus font sizes. Both left and right eyes in the same mannequin had identical font sizes. For each fundus slide, the subjects were allowed one minute to assess, the end point of the examination being locating all six letters on the slide, or the time limit running out. Students worked from the largest font size downwards each time. Students were given an answer sheet which the examiner filled in as they called out the letter and corresponding region. Due to the nature of the prosthetic eyes, only the posterior eye was examined.

The primary outcome of the study was to calculate the total number of letters identified by each device, with a total of 48 letters attainable. The correct number of letters examined in each of the core areas of the fundus were compared in both the TO and Arclight in a binary fashion; 1 point given if students identified the right letter in the correct corresponding region, and 0 points if they did not achieve this.

A questionnaire was then distributed following completion of the study. This allowed qualitative data on the students' perceptions of each device to be collected. Students were asked which device they preferred, which device they would use for future practice, which device they felt gave them the clearest view of the fundus, and which device was more user friendly. Additionally students were asked to rate both devices in terms of simplicity of use and quickness of learning on a seven point Likert scale,

and asked why they gave this rating. This was then analysed using inductive thematic analysis.

The results from a previous study [18] were used for a one sided power calculation, with an estimated mean difference in effect size of 4.15 and standard deviation of 8.90. With an alpha = 0.05 and power = 0.80, the projected sample size was 36. A one sided test was used to detect if the Arclight would be more effective than the traditional ophthalmoscope, thus determining if it could be used in clinical practice.

Statistical analysis was carried out using SPSS version 22 (SPSS, Inc., Chicago, Illinois, USA). Variables are presented as the mean ± standard deviation. Comparisons of baseline results of each device were calculated using Student's t tests. Statistical significance was considered when $p < 0.05$.

Results

40 medical students between the ages of 17 and 29 took part. In Group A, there were 12 females, and 11 males. In Group B there were eight females and nine males. There were two first year students and 21 second year students in Group A, and 11 first year students and six second year students in Group B. Training and assessment was completed by all subjects.

Overall, students who learned the TO first, performed better on second assessment using the Arclight in 100% of cases (Group A). Of students who were taught the Arclight ophthalmoscope first, only 11.8% of students improved on second performance with the TO (Group B). Regardless of group, 92.5% of students performed better with the Arclight ophthalmoscope. Students were assessed comparing four different font sizes. Comparison of the different font sizes showed the greatest discrepancy between font size 2pt. These results can be seen in Figures 1 and 2.

First Period of the Cross-Over Trial

In the first period of the cross-over trial, the mean score using the traditional ophthalmoscope (n=23) was 23.70/48 (49.3%) (sd 9.20), and the mean score using the Arclight ophthalmoscope (n=17) was 40.47/48 (84.3%) (sd 6.88). The difference in results between both instruments, with the Arclight scoring highest was 16.77, 95% C.I. 11.63 - 21.93 A two-sample T test showed T = 6.32, p <0.0001. Results are shown as per each letter identified in Figure 1.

Second Period of the Cross-Over Trial

In the second period of the cross-over trial, the mean score using the Arclight ophthalmoscope (n=23) was 44.26/48 (92.2%) (sd 2.77), and the mean score of the traditional ophthalmoscope (n=17) was 36.24/48 (75.5%) (sd 6.81). The difference in results between both instruments for the second period, with the Arclight scoring highest was 8.02, 95% C.I. 4.52 - 11.52. A two-sample T test showed T = 4.60, p<0.0001. Results are broken down per prosthetic eye slide in Figure 2.

Comparing the two periods of the cross-over trial there was evidence of period-by-treatment interaction. The difference between the instruments reduced by 8.75, 95% C.I. 1.41 - 16.08.
The overall results are shown in Figure 3.

Performance of the traditional ophthalmoscope improved by 52.9% from being used as the device of first exposure, to performance following Arclight exposure. Using the Arclight ophthalmoscope following exposure to the traditional ophthalmoscope showed performance improvement by 9.4%, compared to when just using the Arclight alone.

In Group A there was a 100% improvement rate from the traditional ophthalmoscope to the Arclight ophthalmoscope. In Group B there was an 11.8% improvement rate from the Arclight to the traditional ophthalmoscope. Results can be shown in Figures 4 and 5.

Questionnaire

The questionnaire results were split into three main sections: binary responses where students chose either the Arclight or the traditional ophthalmoscope; students' rationale of choices; and students' perceptions on the teaching they received. There was a 100% response rate from the questionnaire.

Binary responses showed that 82.5% of students preferred the Arclight ophthalmoscope, and 82.5% of students said they would pick the Arclight as the preferred future ophthalmoscope. 77.5% said the Arclight gave a clearer view of the back of the eye, and 80% selected the Arclight as the more user friendly device. The students also thought the Arclight was simpler to use and felt it was quicker to learn.

Students' responses as to why they found each device user friendly, and which instrument they would pick for future practice were themed using inductive thematic analysis.

Students' results were collated and three main themes emerged: "device and functionality", and "visualising the back of the eye" were discussed for both devices, and "ease of use" was only mentioned for the Arclight. Participants felt that the Arclight was lightweight, easier to hold, had fewer settings so was less complex to use, and was more manoeuvrable. Some students however did feel the traditional ophthalmoscope was easier to look through as there was only one piece of visualising apparatus, and others felt the settings were easier to manipulate.

"Ease of use", and "Device and functionality" were the main reasons the Arclight was selected as the preferred future device. Due to its small nature, it was 'easier to operate and handle', and 'easy to get close to the eyes'. The questionnaire concluded that participants agreed that the design established a more portable and lightweight model than the traditional ophthalmoscope [16].

The traditional ophthalmoscope, however, still had its benefits. Some students found the 'controls were more conveniently placed', hence making it 'more easy to zoom/adjust'. The traditional ophthalmoscope has the dials on the side of the device, which students could adjust whilst examining the eye. Additionally, it has only 'one place to look through', when compared to the magnifying loupe and sight hole of the Arclight, which have potential to cause confusion.

The final aspect to the questionnaire explored students' opinions of the teaching method utilised. All students felt that a video tutorial was an appropriate method of teaching such a skill. The majority of students however felt that additional teaching instructions in the form of a checklist or similar would be desirable, due to the complexity of both devices.

Discussion

Use of the traditional direct ophthalmoscope is well established in ophthalmic practice, however medical students should be trained in the most effective way possible. Overall there was a clear indication that students performed more successfully with the Arclight. This study confirms that the introduction to the smaller, more portable Arclight enhances students' performance at ophthalmoscopy, when compared with the traditional device. Results also illustrate that the average performance using the traditional ophthalmoscope improved by 52.9% following exposure to Arclight, than when used alone. Acquiring the skill of ophthalmoscopy using the Arclight was overall easier than with the traditional ophthalmoscope, no matter which device was learned first. This may indeed have considerable implications for medical school teaching if chosen as the device of first exposure. Introducing the Arclight to the curriculum for initial learning could have beneficial effects when students are introduced to the traditional ophthalmoscope in later clinical placements.

These results also suggest that the Arclight could not only be used as an introduction to the traditional ophthalmoscope, but as a replacement for learning ophthalmoscopy within the medical curricula.

The smallest font size provided the greatest discrepancy between the devices. Students' scores using the Arclight were significantly higher. This correlated with questionnaire results, where 77.5% of students admitted having a clearer view of the back of the eye with the Arclight. "Visualising the back of the eye" was a common theme that emerged from the inductive thematic analysis, both for the Arclight being more user friendly, and for reasons why it was picked as the preferred device for future practice. Identification of the smallest font size with such clarity, and in as timely a manner, could predict greater identification of ocular pathology from the Arclight.

Previous studies have introduced the concept that it is unrealistic to expect students to become competent in direct ophthalmoscopy in the short curriculum time frame [5]. This study, however, has shown that students can be taught how to use the Arclight, and use it accurately, in an even shorter time interval than that dictated by the syllabus.

Although many different medical subspecialties vigorously compete for time in the curriculum, an adequate amount must be allotted for learning ophthalmology. This, however, would require taking time from another specialty. The ease, and promptness of learning of the Arclight when compared to a traditional ophthalmoscope, points to it being a reasonable solution to the teaching burden of ophthalmoscopy [1].

The majority of research studies avoid the teaching component of ophthalmoscopy, by assessing already experienced final year medical students or physicians. This study took an alternative perspective, creating a teaching experience for the novice medical student, and an assessment of subsequent performance.

Several limitations have to be taken into account in the research study. Due to the period x treatment interaction, in the presence of a carryover it is useful to look solely, and base analysis, on the first period [19], as if it were a parallel group trial. The design of the cross-over, however, assumes minimal carryover effect of a treatment/skill into the next period. Consequently one could argue that the trial should have proceeded as if there were no carryover, as opposed to testing for it [20]. A washout period was considered in the trial, to leave enough time between each device, as both skills are very similar. Due to the time constraints of the study however, only a maximum of two weeks was permitted between teaching sessions. Students did not have access to either device during the washout period, and subjectively informed us that they had not practiced either ophthalmoscope.

Overall the Arclight achieved better results in every domain assessed. It was the preferred device, better performed device, more user friendly, and in students' opinion, gave a clearer view of the back of the eye. Students also found it easier to learn, and simpler to use than the traditional ophthalmoscope. Additionally, the Arclight was considered to be smaller, more manoeuverable and the settings easier to

manipulate. The majority of participants picked the Arclight as the device they would use for future practice.

Although ophthalmology teaching in the UK[21] and wider world may be diminishing[4], the Arclight could be the answer for training our junior doctors, making ophthalmoscopy an easier skill to acquire. It is clear that the Arclight ophthalmoscope has a place not just in the developing world, but also within our medical curricula, and this may take a number of forms. Whether this be as a replacement for the traditional ophthalmoscope currently used for teaching, as an introduction to ophthalmoscopy prior to training with the traditional direct ophthalmoscope, or as a revision tool, the authors support its ongoing development, research and implementation.

What was known before?

- Whilst variable, time allocated to ophthalmology within medical school curricula is diminishing
- Skills acquisition within such time constraints can be challenging
- Direct ophthalmoscopy represents a particular difficulty

What this study adds?

- Students were found to perform better, and prefer, the Arclight
- Performance using the traditional ophthalmoscope was improved following prior exposure to the Arclight.
- The Arclight may be an effective alternative to the direct ophthalmoscope for teaching around the world

Acknowledgements

The authors acknowledge Professor Jon Dowell, Robert Smith, Mark Smith, Richard Barnes, Peter Davey and Simon Ogston for their support in their various fields.

Conflicts of interest

The authors declare no conflict of interest.

Funding for the purchase of the Arclight ophthalmoscopes was provided by the University of Dundee. No other funding was required for this research project.

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Figure Legends

Figure 1: Mean Number of Letters Identified in Period One. - Total number of participants = 40. Traditional ophthalmoscope (T.O) n=23, Arclight ophthalmoscope n=17. Four different font sizes 8pt, 6pt, 4pt, 2pt were used per prosthetic eye. Total number of letters per slide = six; total number of slides = eight; therefore the total number of letters which could be identified = 48 letters. Results are broken down to show the result of each device per slide. Mean score for T.O. (n=23) = 23.70/48 letters (49.3%) SD 9.20; mean score for Arclight (n=17) = 40.47/48 letters (84.3%) SD 6.88. The total difference in means, was 16.77, 95% C.I 11.63 - 21.93 A two-sample T test showed $p<0.0001$.

Figure 2: Mean Number of Letters Identified in Period Two. - Total number of participants = 40. Arclight n=23; T.O n=17. Four different font sizes 8pt, 6pt, 4pt, 2pt were used per prosthetic eye. Total number of letters per slide = six; total number of slides = eight; therefore the total number of letters which could be identified = 48 letters. Results are broken down to show the results of each device per slide. Mean score for Arclight (n=23) was 44.26/48 letters (92.2%), SD 2.77. Mean score of the T.O. (n=17) was 36.24/48 letters (75.5%) SD 6.81. The total difference in means for the second period was 8.02, 95% C.I. 4.52 - 11.52. A two-sample T test showed $p<0.0001$.

Figure 3: Mean Results in Both Periods of Cross-over Trial - Period one: T.O n=23 (23.70/48 letters), Arclight n=17 (40.47/48 letters). Period two: Arclight n=23 (44.26/48 letters); T.O n=17 (36.24/48 letters).

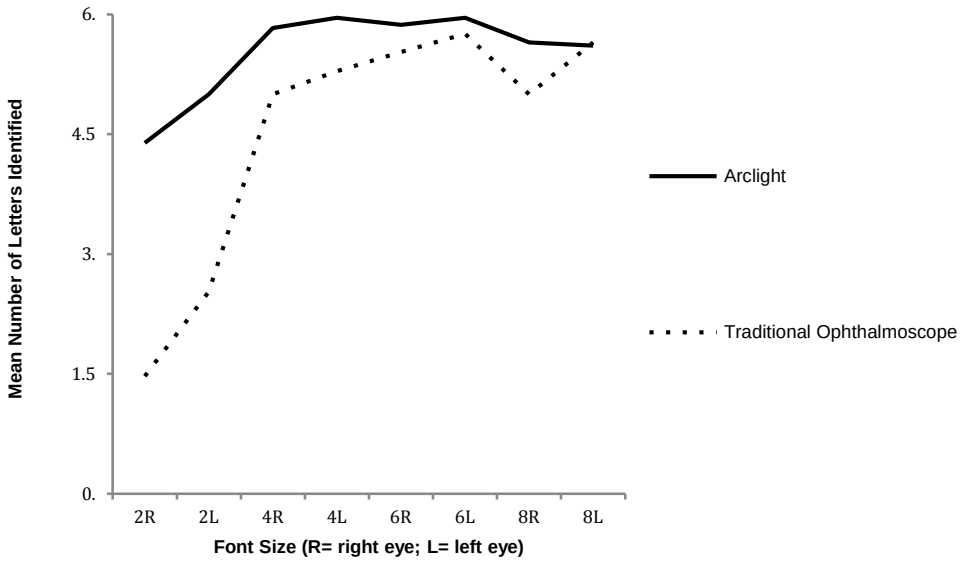
Figure 4: Group A Results - Students were taught how to use the traditional ophthalmoscope followed by Arclight ophthalmoscope. Performance increased by 100%.

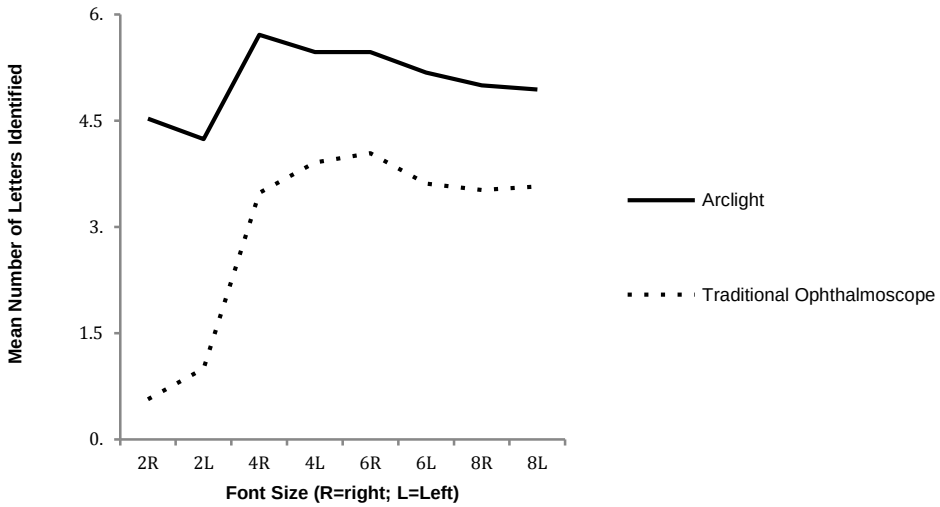
Figure 5: Group B Results - Students were taught how to use the Arclight

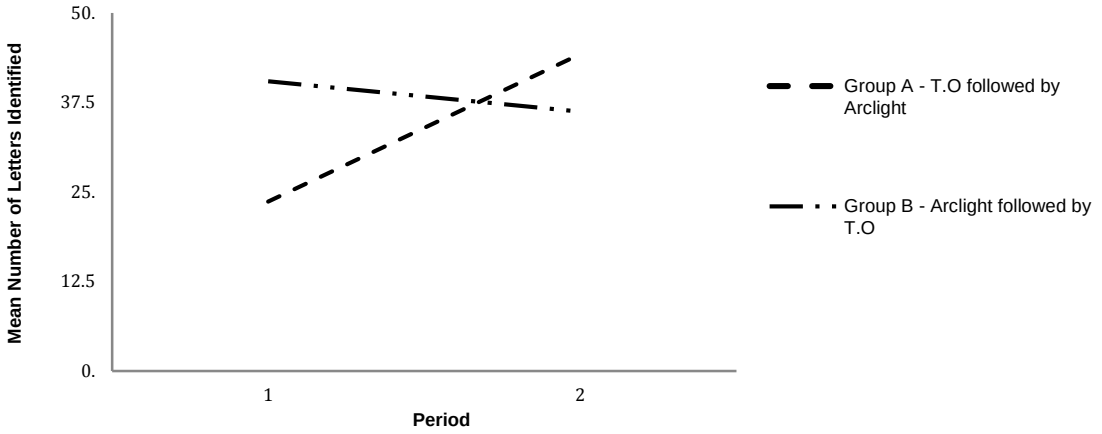
ophthalmoscope followed by traditional ophthalmoscope. There was an 11.8% improvement rate in Group B.

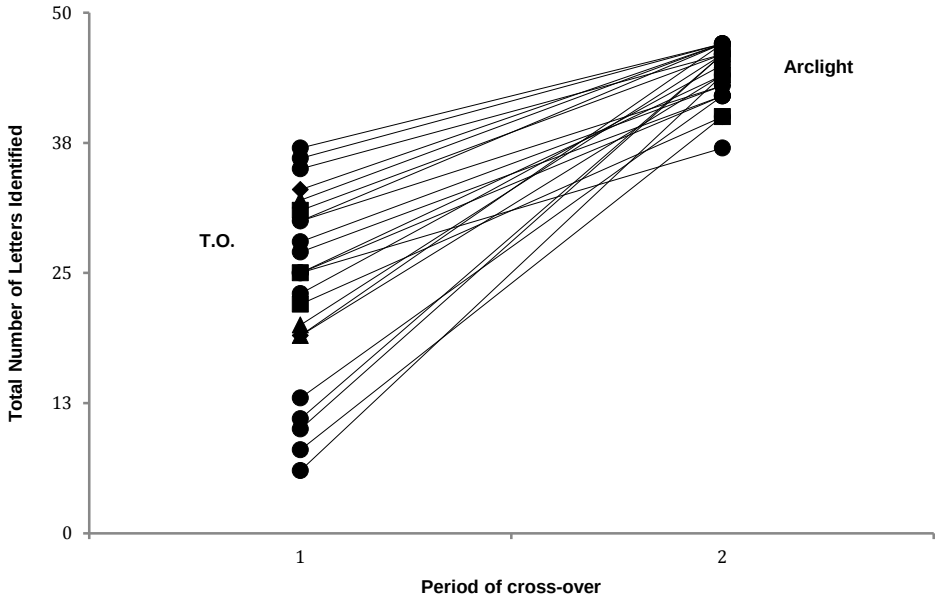
Images

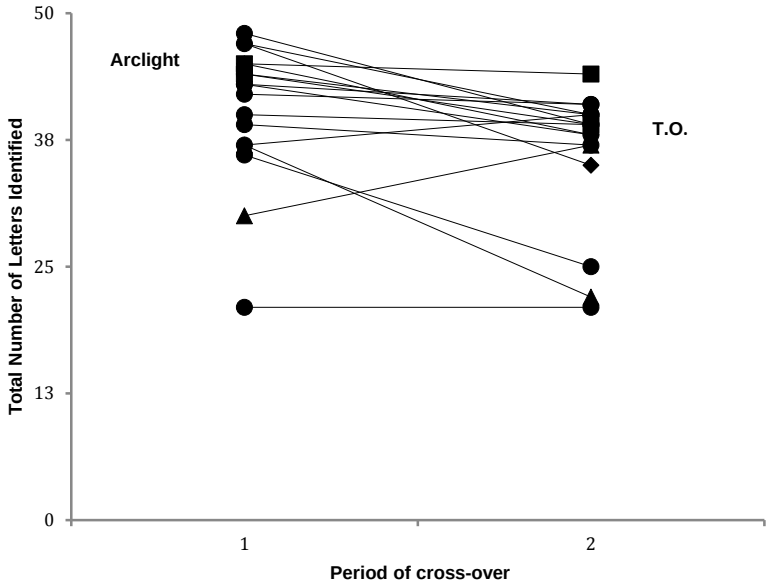
Image 1 – Arclight version 2.0
Image 2 – Arclight version 2.0


6.
4.5
3.
1.5
0.
Mean Number of Letters Identified
2R
2L
4R
4L
6R
6L
8R
8L
Font Size (R= right eye; L= left eye)
Arclight
Traditional Ophthalmoscope


Mean Number of Letters Identified
6.
4.5
3.
1.5
0.
2R
2L
4R
4L
6R
6L
8R
8L
Font Size (R=right; L=Left)
Arclight
Traditional Ophthalmoscope


50.
37.5
25.
12.5
0.
Mean Number of Letters Identified
1
2
Period
Group A - T.O followed by Arclight
Group B - Arclight followed by T.O


50
38
25
13
0
Total Number of Letters Identified
T.O.
Arclight
1
2
Period of cross-over


50
38
25
13
0
Total Number of Letters Identified
Arclight
T.O.
1
2
Period of cross-over


ARCLIGHT
3
6
0
4


2031
81940
471776
14101066