ORIGINAL ARTICLE

Comparing the effectiveness of retina funduscopy using direct ophthalmoscope and handheld non-mydriatic digital retina fundus camera in medical practice

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ABSTRACT

Introduction: Retinal examination plays an essential role in ocular assessment and serves as a key tool for diagnosing various eye conditions. The traditional direct ophthalmoscope (DO) remains widely used due to its affordability, accessibility, and rapid application. However, it presents several limitations, including a steep learning curve, narrow field of view, and strong dependence on user expertise. In contrast, the handheld fundus camera (HFC) is a newer innovation that provides high-resolution digital imaging and is more user-friendly. This study compared the usability, diagnostic confidence, and user preference between the DO and HFC among medical students and practitioners.

Materials and Methods: This quasi-experimental study was conducted among 70 participants comprising medical students and practitioners. All participants had prior exposure to the DO and were recruited through convenience sampling. The study took place at the Faculty of Medicine and Health Sciences, Universiti Sains Islam Malaysia (USIM), Negeri Sembilan and USIM's mobile eye screening sites. Participants received a 15-minute hands-on training with both the DO (Welch Allyn) and HFC (New Eyes) before performing non-mydriatic retinal examinations on separate patients. A structured questionnaire was used to assess device usability, comfort, diagnostic confidence, ability to identify retinal structures, and System Usability Scale (SUS) scores. Data were analysed using paired t-tests, Fisher's exact test, and chi-square tests.

Results: Among the participants, 70% were female and 62.9% were medical students. The mean(SD) time to identify retinal structures was significantly shorter with the HFC (2.8(1.84) minutes) compared to the DO (6.4(5.77) minutes; p<0.001). While red reflex detection was higher with the DO (97.1%), the HFC significantly outperformed in locating key structures: optic nerve (88.6% vs. 42.9%, p<0.001) and fovea (82.9% vs. 41.4%, p<0.001). No significant difference was found in identifying retinal vessels. Confidence in findings (92.9% vs. 32.9%) and image clarity (94.3% vs. 45.7%) favoured the HFC, with both differences being statistically significant (p<0.001). The HFC scored higher in usability with a mean SUS score of 64.0(9.37) versus 58.6(9.91) for the DO (p<0.001). Notably, 97.1% of participants preferred the HFC over the DO.

Conclusion: Our findings show that the HFC offers clear advantages over the traditional DO, especially in ease of use, diagnostic confidence, and user experience. These strengths make it a more effective tool in clinical practice and medical education

KEYWORDS:
Handheld fundus camera, direct ophthalmoscope, retinal examination, diagnostic confidence, medical education, usability, System Usability Scale

INTRODUCTION

Diagnostic technologies in the ophthalmology field have undergone significant advancements over the past few decades. The innovation has led to the development of new diagnostic tools, which are more accurate, effective, and user-friendly. Consequently, it improves clinical confidence, preference and patient outcomes. The DO and the HFC have emerged as key tools in clinical practice. Invented in 1851 by Hermann von Helmholtz, the DO has long been used for ophthalmic diagnosis among medical practitioners. It is an essential component in the ophthalmology medical curriculum for undergraduate medical students, particularly for examining the fundus.[1,2] Despite its widespread use, effective utilisation of the DO requires significant skill and presents a notable learning curve.[3] This challenge is particularly pronounced among those with limited hands-on experience.

Several studies have reported that many medical practitioners exhibit low confidence when using DO, which may impact diagnoses accuracy and consequently, patient treatment.[4,5] Introduced in the early 20th century, the HFC represents a modern approach to retinal imaging. It captures high-resolution digital images of the retina, enabling more accurate and precise examination.[6] The device is user-friendly and produces superior image quality, which enhances practitioner confidence and contributes to a growing preference for its use.[7] Medical practitioners and students often find the HFC more accessible and cost-effective, especially in educational settings, where ease of use and immediate feedback are crucial for skill development.[8] Retinal fundus viewing is essential for diagnoses, management and prevention of blindness as well as in detecting life-threatening conditions. A thorough understanding of retinal

This article was accepted: 23 June 2025
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anatomy and accurate interpretation of fundus images are fundamental for building diagnostic confidence and providing appropriate management.

Despite the advancements in ophthalmic diagnostic tools, a major challenge remains in ensuring medical professionals and students are adequately trained and confident in using these technologies. Evidence also suggests that user confidence in using diagnostic tools directly correlates with the accuracy of clinical assessments.[4,9] However, the integration of such advanced tools into medical training programs remains inconsistent, and there is a need for comprehensive studies to evaluate their impact on diagnostic performance and clinical outcomes. This study aims to evaluate and compare the image quality, confidence levels and preferences of medical professionals and students in using the DO and the HFC. By highlighting the differences in how each tool is experienced, especially in terms of ease and effectiveness, we hope to offer practical insights that can help improve both teaching and clinical practice.

MATERIALS AND METHODS

Ethical Approval

Ethical approval was obtained from the USIM Ethics Committee (grant code: PPPI/FPSK/0122/USIM/14122) and adhered to the Declaration of Helsinki and ICH guidelines for good clinical practice. Written informed consent was obtained from all study participants.

Participants

Participants, including medical doctors and students, were recruited through convenience sampling. The participants were medical doctors from both private and government facilities, medical officers participating in Universiti Sains Islam Malaysia (USIM) mobile eye screening program in Negeri Sembilan, medical lecturers from the Faculty of Medicine and Health Sciences USIM, and general practitioners. Additionally, medical students from USIM who have completed their ophthalmology postings were also included. Participants must also have prior training with a DO. Ophthalmologists and ophthalmology trainees were excluded from the study.

The study took place at the USIM mobile eye screening sites in Negeri Sembilan and the Faculty of Medicine and Health Sciences, USIM, in Nilai, Negeri Sembilan. The sample size was calculated based on a study conducted in the United States comparing direct ophthalmoscope and digital smartphone opthalmoscope.[10] A minimum sample size of 70 participants was calculated using Open Epi (95% Confidence Interval, 80% power and significant level of 0.05) based on the success rates of identifying retinal structures using both devices (50.0% for direct ophthalmoscope and 82.3% for digital smartphone ophthalmoscope).[11]

Study flow

The participants were randomly assigned to use either the DO or the HFC first. They received a 15-minute demonstration and practice session on the assigned device before the evaluation. Each participant conducted a timed retinal fundus examination on a non-dilated normal patient and subsequently complete a questionnaire about their experience. Afterward, participants were then given other device and assigned to different patients to avoid bias.

The study utilized a DO and a HFC testing device, along with a questionnaire. This questionnaire included basic demographic information as well as the ability to identify ocular structures, confidence of findings, image sharpness, comfort level and device preference for both DO and HFC. The System Usability Scale (SUS) was used to measure comfort level. The SUS is a validated tool for evaluating a product, system or service.[12] Each item is scored using a 10-point Likert scale from "strongly disagree" to "strongly agree". The scoring is calculated by adding all the 10 items scores resulting in a score ranging from 10-100.[12,13]

Statistical Analysis

Data was analysed using Statistical Package for Social Science (SPSS), version 22.0 (IBM Corp, USA). Continuous data was presented as mean (SD), and categorical data was presented as frequency and percentages (%). A paired t-test was used to compare the duration taken for examination in minutes and the total SUS score between both devices. The ability to visualize retinal structure and confidence level were evaluated using Fisher's exact and chi-square test.

RESULTS

A total of 70 participants were recruited for the study with the highest being Malays (65%), followed by Indian (4%) and Dusun (1.4%). The majority (70%) of the participants were female and 60% were myopic. The participants were medical practitioners (37.1%) and medical students (62.9%). The medical practitioners consisted of medical lecturers, general practitioners and non-ophthalmology medical officers. The mean(SD) age of the participants was 27.5(6.06) years old. More than half (57.1%) had 5-10 years' experience as medical students and in-service doctors. The majority of the participants (71.4%) used a DO in the past 6 months.

Table II presents a comparison of retinal structure visualization, examination duration, and user confidence between the DO and the HFC. The duration of finding retinal structures was significantly longer using the DO (6.4 minutes(5.77) compared to the HFC (2.8 minutes (1.84). The DO gave the user higher ability (97.1%) in eliciting red reflex compared to the HFC (64.3%). The ability to find the optic nerve was higher in the HFC at 88.6% compared to 42.9% using the DO. The result was relatively similar to finding the fovea using the DO and the HFC with percentages of 41.4% and 82.9% respectively. However, there was no significant difference in finding the retinal vessel using both equipment. The results showed that users of HFC reported higher confidence of the correct findings (92.9%) and confidence of the sharpness of the image (94.3%).

Table III summarises the results of the SUS scores for both DO and HFC. The HFC outperforms the DO in preference for ease of usage, integrated function, ease of learning and usage confidence. The difference in the SUS scores was statistically significant with a mean difference of 5.39 (Table IV). The HFC was perceived as more user-friendly and gives more confidence to the users.

Table I: Sociodemographic profiles of the participants

Characteristics	n	%
Race		
Malay	65	92.9
India	4	5.7
Dusun	1	1.4
Gender		
Female	49	70
Male	21	30
Refractive Status		
Emmetrope	28	40
Myopia	42	60
Occupation		
Medical Practitioner	26	37.1
Medical Student	44	62.9
Duration of study and employment		
Less until less than 5 years	23	32.9
5-10 years	40	57.1
More than 10 years	6	8.6
Missing	1	1.4
When was the last time you used direct ophthalmoscope?		
Less than 6 months	50	71.4
6 months to less than 1 year	4	5.7
1-2 years	2	2.9
More than 2 years to 3 years	3	4.3
More than 3 years	11	15.7

Table II: Comparison of Retinal Structure Visualization, Examination Duration, and User Confidence Between Direct Ophthalmoscope (DO) and Handheld Fundus Camera (HFC) Among Medical Practitioners

	DO	HFC	p-value
	Mean (SD)	Mean (SD)	
Duration taken for examination (in minutes)	6.4(5.77)	2.8(1.84)	<0.001[a]
N (%)	N (%)	p-value	
Able to get red reflex			
Yes	68 (97.1)	45 (64.3)	<0.001[b]
No	2 (2.9)	25 (35.7)	
Optic nerve			
Yes	30 (42.9)	62 (88.6)	<0.001[c]
No	40 (57.1)	8 (11.4)	
Retinal vessel			
Yes	64 (91.4)	67 (95.7)	0.49
No	6 (8.6)	3 (4.3)	
Fovea using			
Yes	29 (41.4)	58 (82.9)	<0.001[c]
No	41 (58.6)	12 (17.1)	
Confident of correct finding			
Yes	23 (32.9)	65 (92.9)	<0.001[c]
No	38 (54.3)	5 (7.1)	
Confident sharpness of image			
Yes	32 (45.7)	66 (94.3)	<0.001[c]
No	38 (54.3)	4 (5.7)	

[a]paired t-test, [b]fisher exact test, [c]chi square

In terms of overall preference, 68 (97%) indicated a preference for the HFC, while only 2 (3%) preferred the DO. This strong preference for the HFC underscores its perceived advantages in usability, image clarity, and ease of operation

DISCUSSION

Retinal examination remains an important part of diagnosing and managing various eye diseases. Although the DO has been used for many years, it still poses challenges, especially in teaching and routine clinical use. Recent technologies with more user-friendly devices such as HFC have been introduced as they offer better ways to improve the user experience and support learning, particularly for those still in training. Therefore, evidence to support the learning outcomes in the local context is important to justify introducing new devices in teaching.

Gender distribution among the participants showed a predominance of females (70%) compared to males (30%).

Table III: Comparison of Systems Usability Scale (SUS) Scores Between Direct Ophthalmoscope and Handheld Fundus Camera

	DO	HFC	Mean difference (SD)	p-value
	Score (1-10) Mean (SD)	Score (1-10) Mean (SD)		
I think I would like to use this system frequently	6.0 (2.78)	9.1 (1.32)	-3.1 (3.00)	<0.001
I found the system unnecessarily complex	5.6 (3.05)	3.6 (2.52)	2.0 (3.26)	<0.001
I thought the system was easy to use	6.1 (2.82)	9.1 (1.36)	-3.0 (3.07)	<0.001
I think that I would need the support of a technical person to be able to use this system	5.4 (3.03)	4.5 (2.70)	0.9 (3.18)	0.016
I found the various functions in this system were well integrated	6.9 (2.28)	8.6 (1.46)	-1.8 (2.34)	<0.001
I thought there was too much inconsistency in this system	5.6 (2.87)	3.4 (3.22)	2.2 (3.22)	<0.001
I would imagine that most people would learn to use this system very quickly	5.4 (2.90)	8.9 (1.54)	-3.5 (3.16)	<0.001
I found the system very cumbersome to use	5.5 (2.86)	3.6 (2.53)	1.81 (3.49)	<0.001
I felt very confident using the system	5.5 (2.82)	8.8 (1.56)	-3.3 (3.06)	<0.001
I needed to learn a lot of things before I could get going with this system	6.7 (2.69)	4.3 (2.69)	2.4 (3.22)	<0.001

paired t-test

Table IV: Comparison of Total System Usability Scale (SUS) Scores Between Direct Ophthalmoscope and Handheld Fundus Camera

Total SUS score	Mean score	SD	Mean difference	95% CI	p-value
Direct Ophthalmoscopy	58.6	9.91	-5.39	-7.36, -3.40	<0.001
Handheld fundus camera	64.0	9.37			

paired t-test

This reflects current demographic trends within healthcare training programs. This gender imbalance might influence the comfort and usability ratings of the devices, as different ergonomic preferences could exist between genders. Future studies with more balanced gender representation would help to clarify the potential influence from this gender factor. Secondly, regarding refractive status, 60% of the participants were myopic, while 40% were emmetropic. Myopic participants depend on corrective lenses, which can influence comfort and effectiveness while using HFC. However, no significant difference in device preference or usability was observed between myopic and emmetropic participants in this study.

Apart from that, the recent use of the DO played a role in mastering a new device such as HFC. This can be seen as more than half of the participants (71.4%) reported that they have used DO within the last 6 months. This indicates that most participants are actively engaged in clinical practices where ophthalmoscopy examination is routinely performed and are already familiar with the DO. The user-friendly nature of HFC could be a beneficial addition, especially for those who did not use ophthalmoscopes frequently. This could further enhance the efficiency and comfort in retinal examinations.

In comparing the device performance, the DO showed a higher success rate of red reflex detection (97.1%), however this did not translate into better visualization of deeper retinal structures. The optical properties of DO, including its coaxial illumination aligned with the viewing axis, allows for the pupils to be illuminated as light reflects off the back of the retina and through the aperture of the scope.[14] For the examination of the optic nerve and fovea, the HFC showed significantly higher rates of optic nerve (88.6% vs. 42.9%) and fovea (82.9% vs. 41.4%) identification with no significant difference in detecting retinal vessels. In contrast, both devices performed similarly for retinal vessel visibility, a finding supported by previous research that highlights the adequacy of both tools for vascular assessments.[10,14] These findings are consistent with previous studies reporting that digital fundus cameras and ophthalmoscopes offer better visibility of key retinal landmarks compared to the DO.[10,16,17]

Beyond image clarity, the HFC also allowed significantly faster completion of retinal examinations (mean 2.8 minutes) than the DO (mean 6.4 minutes). This finding is consistent with previous studies which demonstrated that digital fundus camera and smartphone-based ophthalmoscopes not only allow faster identification of ocular structure, but also generally easier to use.[10,16,18] The HFC allows for examination without pupil dilatation, has autofocus capability, captures and stores images, and has a wide field of view. These features make the retinal examination quicker. While the DO remains valuable for red reflex detection, the HFC provides clearer imaging of key retinal landmarks, supporting more accurate diagnosis and learning. Future integration of red reflex functionality into fundus cameras could further enhance their versatility and clinical application.

Diagnostic confidence and perceived image quality were also significantly higher when using the HFC. A total of 92.9% of participants reported confidence in their findings with the HFC, compared to 32.9% with the DO. Confidence in image sharpness was similarly higher respectively (94.3% vs. 45.7%). This is supported by a study comparing the traditional DO with a non-mydriatic automatic fundus

camera among medical students. None of the students were able to visualize the macula using the DO, whereas all were able to do so with the automatic fundus camera. Moreover, diagnostic accuracy for diabetic retinopathy improved significantly by 100% with the automatic camera versus 40% with the direct ophthalmoscope. Students also expressed greater confidence in identifying basic retinal anatomy using the automatic camera (9.6/10 vs. 6.4/10).[15] The integration of HFCs into ophthalmology teaching could therefore enhance both the learning experience and diagnostic competence of future clinicians.

Building on the usability findings, user preference was also overwhelmingly in favour of the HFC. Most notably, 97.1% of participants preferred the HFC over the DO , with only 2.9% indicating a preference for the latter. This overwhelming preference reflects the cumulative advantage of the HFC in ease of use, image quality, diagnostic confidence, and time efficiency. It also underscores a shift in user expectations toward more modern, digital diagnostic tools. These findings align with previous research showing that non-mydriatics fundus cameras produce high-quality images that aid in diagnosis and monitoring with better patient experience.[19,20]

While this study provides valuable insights into the usability and diagnostic confidence associated with the DO and HFC, several limitations must be acknowledged. Firstly, convenience sampling was used to recruit participants, which may have introduced some selection bias. Those who volunteered could have had more interest or prior exposure to eye examinations, potentially influencing their confidence and preference. The study used a specific model of HFC (New Eyes) and a particular brand of DO (Welch Allyn). The results may differ with other models or brands, limiting the applicability across all available devices. Additionally, our assessments were limited to a short-term, post-training evaluation. Long-term use and retention of skills over time were not assessed. Another important limitation is the cost difference between the devices; the HFC is substantially more expensive than the DO, which could pose challenges for widespread adoption, particularly in resource-limited settings or for large-scale implementation in undergraduate medical training.

Based on the limitations of this study, we suggest a few areas for future research and improvement in clinical practice. First, future studies should consider using random sampling and involving a more diverse group of participants with different levels of experience. This would increase the representation and reliability of the study. Secondly, while a brief standardized training session was sufficient for this study, longer-term training or follow-up assessments could help evaluate the retention of skills over time. To improve external validity, future research should also include comparisons involving different models and brands of handheld fundus cameras and direct ophthalmoscopes.

Finally, this study has valuable implications for both teaching and clinical practice. The HFC's intuitive design and diagnostic advantages make it a strong candidate for integration into undergraduate ophthalmology training. Its digital capabilities support self-directed learning, documentation, and teleconsultation for all essential skills in today's healthcare environment. For clinical settings, especially in community and mobile outreach programs, the HFC provides a reliable and efficient tool for early detection and monitoring of retinal disease.

CONCLUSION

This study demonstrates a strong preference for the HFC among medical professionals and students, with significantly better performance in image quality, ease of use, and user confidence compared to the DO. The high SUS scores and clear user preference highlight the HFC's potential as a more effective diagnostic tool. These results support the integration of HFCs into undergraduate ophthalmology training and wider clinical practice, particularly in settings where user-friendliness and efficiency are essential. Further research should explore the long-term impact, cost-effectiveness, and influence of these devices on clinical decision-making and patient outcomes.

ACKNOWLEDGEMENTS

We would like to thank the Faculty of Medicine and Health Sciences, USIM, for their support in conducting this study. This research was funded by the USIM Research Grant (Grant code: PPPI/FPSK/0122/USIM/14122). We are also grateful to all participants who contributed their time and effort to this project.

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