The demise of direct ophthalmoscopy

A modern clinical challenge

Devin D. Mackay, MD

Philip S. Garza, BS

Beau B. Bruce, MD, MS

Nancy J. Newman, MD

Valérie Biousse, MD

Summary

Ocular funduscopy appears to be a dying art. Physicians and medical students alike lack confidence in the use of an ophthalmoscope. As a result, few clinicians perform ophthalmoscopy, and many who do are unable to reliably detect abnormalities of the ocular fundus. Approaches to remediation in undergraduate medical education have included simulators, longitudinal skill reinforcement, Web-based teaching, and other techniques. Preservation of the ophthalmoscopic art has been hindered by technical difficulty, waning enthusiasm for ophthalmoscopy, and even discouragement from preceptors in medical education. Ocular fundus photography may serve a role in medical education to help improve student confidence in interpretation of ocular fundus findings and improve awareness of the importance of examination of the ocular fundus. Because neurology clerkships and clinical practices remain an important forum for honing ocular funduscopy skills, the neurologist should be familiar with novel alternative techniques that facilitate examination of the ocular fundus.

The first report of living ocular fundus examination with a direct ophthalmoscope by Hermann von Helmholtz in 1851 dramatically changed the practice of medicine. The newly afforded view of the living ocular fundus immediately inspired a golden age of ophthalmology that included the first in vivo descriptions of central retinal artery occlusion in 1855, papilledema in 1860, and optic disc atrophy in 1861 (figure 1).¹ The importance of the ocular fundus examination to the clinical practice of neurology was

Departments of Neurology, Ophthalmology, and Neurosurgery (DDM), Indiana University School of Medicine, Indianapolis, IN. Departments of Ophthalmology (PSG, BBB, NJN, VB), Neurology (BBB, NJN, VB), and Neurological Surgery (NJN), Emory University School of Medicine; and Department of Epidemiology (BBB), Rollins School of Public Health and Laney Graduate School, Emory University, Atlanta, GA.

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Correspondence to: vbiousse@emory.edu

Figure 1 The history of ocular fundus examination

The invention of the ophthalmoscope inspired a golden age of ophthalmology and paved the way for in vivo fundus-copy to influence clinical care. Other technological developments, including ocular fundus photography, have been developed more recently and may be useful in preserving the ocular fundus examination.

appreciated by Charcot,² who was an early adopter of the ophthalmoscope and found it useful in diagnostic dilemmas, noting “Now in this difficulty, the ophthalmoscopic art came to give us its decisive aid.”

Ophthalmoscopy became an integral part of the general physical examination and was eventually incorporated into medical education. However, ophthalmology content in medical education and non-ophthalmologist physician and student proficiency with ophthalmoscopy have declined in tandem over a period of several decades.³ Additionally, there is evidence that direct ophthalmoscopy, even by ophthalmologists, is inadequate for screening for diabetic retinopathy, glaucoma, and hypertensive retinopathy.⁴ However, ocular fundus examination yields important information and influences clinical decision-making and patient outcomes. Given the poor proficiency of most physicians with ophthalmoscopy, the future of the examination of the ocular fundus is uncertain and presents a modern clinical challenge.

A leap in technology over the past several decades has led to unprecedented advancements in both the diagnosis and treatment of disease. Advancements in ocular fundus photography technology now allow for the acquisition of high-quality fundus photographs with a field of view of approximately 45° without pupillary dilation or extensive training (figure 2).⁵ Recent reviews have emphasized the use of nonmydriatic fundus photography in the evaluation of acute neurologic conditions and suggest that it has the potential to improve neurologic care by facilitating the ocular fundus examination by bypassing the use of direct ophthalmoscopy in neurologic patients.⁶ The introduction of this relatively new technology has also presented opportunities to reform traditional approaches to teaching the ocular fundus examination in medical education.

Ophthalmoscopy in clinical practice

Advantages of direct ophthalmoscopy have traditionally included (1) a 15× magnified view of the posterior pole that facilitates appreciation of small, dynamic changes of the ocular fundus, such as venous pulsations and circulatory changes; (2) wide availability and portability—the direct ophthalmoscope is easily carried in the pocket of a clinician’s coat and can be used in settings where other methods of ocular fundus examination are unavailable; (3) relatively low

Figure 2 Nonmydriatic ocular fundus photography vs classic direct ophthalmoscopy

(A) Nonmydriatic ocular fundus photography. (B) Classic direct ophthalmology. The 45° field of view from the nonmydriatic fundus photograph allows simultaneous examination of the optic disc, macula, and major vascular arcades. The 5° view (15× magnification) from the classic direct ophthalmoscope is useful for detailed, but isolated, examination of the optic disc margins, the macula, and dynamic phenomena such as venous pulsations when centered on the optic disc, but adds difficulty to the integrated examination of the retina and other details of the ocular fundus.

cost; (4) its practicality as a tool for ocular fundus examination in critical care patients; and (5) its potential usefulness in the examination of low-amplitude nystagmus and subtle abnormalities of visual fixation. However, direct ophthalmoscopy, particularly through an undilated pupil, is difficult to master and requires considerable practice to attain the level of proficiency needed to reliably detect relevant ocular fundus findings. The classic direct ophthalmoscope's 5° field of view is too small to resolve all of the relevant details of the optic disc and retina at once and thus requires the examiner to search for relevant findings (figure 2). The PanOptic direct ophthalmoscope (Welch Allyn, Skaneateles Falls, NY) was introduced in 2001 and may provide up to a 25° field of view, which results in a wider, but less magnified view of the optic disc. Pharmacologic pupillary dilation is essential to an accurate funduscopic examination and may take 30 minutes or longer. In a practice climate overshadowed by increasing time pressures, clinicians in busy practices are unlikely to spend the extra time necessary to perform a thorough funduscopic examination. Even when direct ophthalmoscopy is performed, students and physicians demonstrate a lack of confidence in their findings, further minimizing the ability of the ocular fundus examination to positively affect patient care.⁷

Ophthalmoscopy has long been considered an essential part of the physical examination in patients with headache. Whereas most patients with headache who visit an emergency department have a primary headache syndrome, the detection of optic disc edema is indispensable in determining which patients have a more serious underlying cause. Patients from the Fundus photography vs Ophthalmoscopy Trial Outcomes in the Emergency Department (FOTO-ED) study were the subject of a recent study in which ocular fundus photographs were used to determine the rate and predictors of abnormal ocular fundus findings among patients with headache in an emergency department setting.⁸ Of the 497 patients in the study with headache, 42 (8.5%) had relevant ocular fundus abnormalities, including isolated retinal hemorrhages, optic disc edema, grade III or IV hypertensive retinopathy, and optic disc pallor. Importantly, many of the patients with ocular fundus abnormalities had unremarkable physical examinations and 41% had normal neuroimaging studies, reinforcing the critical role of ocular funduscopy in patients with headache.

Ocular fundus examination is particularly important for neurologists, as the identification of papilledema, optic disc pallor, or retinal vascular occlusion can lead to life- and vision-saving interventions. Recent evidence suggests that even mild abnormalities of the ocular fundus, which may

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easily be missed with direct ophthalmoscopy through an undilated pupil, may have important implications for neurologists. For example, patients with a TIA or acute stroke are more likely to have visible abnormal retinal microvascular signs than the general population.⁹ Additionally, fundus photography may have a role in stroke risk assessment by screening for signs of microvascular retinal disease.

Advantages of ocular fundus photography include its ease of use, its ability to document a patient's ocular fundus appearance as a baseline for future comparison, the ability to electronically magnify regions of interest in photographs, the ability to archive and send photographs electronically, and the great potential of fundus photography as an educational tool. The nonmydriatic fundus camera's current limitations of cost, portability, and limited application in the critical care setting are likely to become less relevant as innovation continues to propel the technology's rapid evolution.

Ophthalmoscopy in medical student education

Standards adopted by the Association of University Professors in Ophthalmology and endorsed by the American Academy of Ophthalmology and the International Council of Ophthalmology recommend that all graduating medical students in the United States be able to recognize key abnormalities of the ocular fundus using a direct ophthalmoscope.¹⁰ Despite these standards, direct ophthalmoscopy is performed infrequently and often inaccurately by medical students and residents. There is very little ophthalmology in most standard medical school curricula, making it difficult to teach ophthalmoscopy. Over the past 10 years, various studies have characterized medical students' difficulties with direct ophthalmoscopy and potential interventions (table).

As interest in and reliance on direct ophthalmoscopy has waned over time, nonmydriatic fundus photography has emerged as an alternative method of ocular fundus examination. While there are data demonstrating the increased efficacy of nonmydriatic fundus photography over direct ophthalmoscopy in the emergency department setting,⁵ the role of fundus photography in medical education had not been studied until recently.^{7,11}

The Teaching Ophthalmoscopy to Medical Students (TOTeMS) study used a prospective, randomized design to compare the accuracy and preferences of medical students learning to examine the ocular fundus using various modalities.⁷ First-year medical students were randomized to receive or not receive training on fundus photograph interpretation prior to accuracy assessments. Student preferences for ocular fundus examination with a human volunteer, a simulator, and fundus photographs were assessed. Of 119 medical students, 92 (77%) preferred fundus photography over ophthalmoscopy. Students were also more accurate when interpreting fundus photographs than when performing ophthalmoscopy on simulators, even without further training. Not surprisingly, students rated interpreting fundus photographs as easier and less frustrating than ophthalmoscopy on humans or simulators. The majority of students (70%) indicated they would prefer to use fundus photographs over direct ophthalmoscopy during clinical rotations.

A 1-year follow-up study (TOTeMS II) with the same cohort of students demonstrated that the students' preference for fundus photographs and increased accuracy when using photographs over direct ophthalmoscopy persisted over time with no additional interval training.¹¹

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Of the 119 students who participated in the original TOTeMS study, 107 (90%) completed the follow-up study and were randomized to fundus examination using photographs or direct ophthalmoscopy on simulators. Students were again more accurate using photographs for fundus interpretation than direct ophthalmoscopy using simulators, although both groups performed worse than 1 year prior. The interval performance decline likely reflected a lack of interval skill reinforcement in ocular fundus examination. The students rated interpretation of fundus photographs as easier than ophthalmoscopy and 81 (76%) stated they would prefer using photographs over ophthalmoscopy for ocular fundus examination. The students' self-reported median frequency of ophthalmoscopy during physical examinations over the previous year was <10%. Discomfort with the ophthalmoscopic examination (41/107; 38%) and discouragement by their preceptor (21/107; 20%) were the most common primary reasons for not examining the ocular fundus during a physical examination. The surprising finding of discouragement from preceptors as a primary reason for not performing ophthalmoscopy suggests that substantial barriers to the performance of ophthalmoscopy persist in clinical practice.

Although ocular fundus photography requires the patient to be alert and cooperative and therefore cannot always replace the direct ophthalmoscope in critical care settings, nonmydriatic ocular fundus photography is poised to be an effective alternative to direct ophthalmoscopy in many non-ophthalmology acute and primary care settings. For example, fundus photography is already used in some primary care settings to screen for diabetic retinopathy.⁶ Fundus photography may be a welcome addition to undergraduate medical education as a tool that increases students' enthusiasm for ocular fundus examination at a time when ophthalmoscopy instruction has been increasingly marginalized in medical school curricula.

Two fundamental problems underlie the demise of ophthalmoscopy: the technical difficulty of using the ophthalmoscope and the difficulty of interpreting the findings. The use of fundus photographs in medical education would relieve the technical obstacle of ophthalmoscopy and allow students to focus more on the interpretation of what they see. In an increasingly digital world, there are abundant opportunities to reinforce the teaching of ocular fundus interpretation with Web-based resources, hand-held electronic study aids, and other techniques.

Digital fundus photography technology has been following the trends of other consumer electronics in becoming smaller, more portable, less expensive, and more user-friendly. These trends have inspired the development of handheld nonmydriatic fundus cameras that are now commercially available, as well as devices designed to attach a smartphone camera directly to an ophthalmoscope to obtain photographs of the ocular fundus. Handheld cameras are also available for bedside examination of young children or patients unable to sit up such as those in the intensive care unit. Digital video can also be obtained using fundus cameras to allow visualization of dynamic features of the ocular fundus, such as venous pulsations and retinal circulatory changes. It is likely that such technology will be further refined in the near future to further reduce cost, improve image quality, and increase portability, which will remove many of the existing barriers to more widespread adoption of nonmydriatic fundus photography. The introduction of fundus photography in medical education may help prepare the rising generation of clinicians for the exciting technological advancements in ocular fundus examination that lie ahead.

Table Selected direct ophthalmoscopy studies in medical students published between 2004 and 2014

Reference	Medical student year	No.	Pupillary dilation?	Assessment method	Examination subjects	Conclusions
13	1	8 students, 10 subjects, 288 eye examinations (111 using classic direct ophthalmoscope, 140 using panoptic direct ophthalmoscope)	Both dilated and undilated	Assessment of accuracy and ease of use in determining cup-to-disc ratio using panoptic vs classic ophthalmoscope	Live volunteers (mostly peers)	Students preferred the panoptic, but there was no difference in accuracy between panoptic and classic ophthalmoscope groups
14	3–4	96	Both dilated and undilated	Clinical Performance Examination standardized examination	Funduscopy simulator	Ophthalmoscopy performance improves immediately following skill reinforcement
12	3	84	Yes	Clinical Performance Examination standardized examination	Funduscopy simulator	Ophthalmoscopy skills decay when not habitually practiced
15	4	33	No	Matching fundus photographs with live fundus before and after 1 week ophthalmology clerkship	Live volunteers	Matching exercise may increase ophthalmoscopy skills and be helpful in assessing how well students visualize the optic nerve
16	Unknown	394	No	Internet-based matching of live fundus examination with photographs	Live volunteers (peers)	Internet-based software may be used for ophthalmoscopy skill assessment
17	2	20 (10 study, 10 control)	Both dilated and undilated	Identification of cup-to-disc ratio	Live volunteers (peers)	Students performed slightly better in cup-to-disc ratio estimation using a lens-free instead of classic direct ophthalmoscope
18	Unknown	129	Both dilated and undilated	Reading 3.28-point font on fundus photographs	Funduscopy simulator	Enhanced direct ophthalmoscopy skills immediately after using canister simulator
19	4	131	No	Matching live fundus examination with photographs	Live volunteers (peers)	Improvement in ophthalmoscopy skills over 1 week using teaching exercise
7	1	119	Yes for training, no for assessment	Multiple choice questions based on fundus examination	Live volunteers, simulators, and fundus photographs	Students are more accurate with and prefer fundus photographs over direct ophthalmoscopy
11	2 (same cohort as Kelly et al. ⁷)	107	No	Multiple choice questions based on fundus examination	Simulators and fundus photographs	Students are more accurate with and prefer fundus photographs over direct ophthalmoscopy 1 year after initial training
20	2	10 (5 study, 5 control)	Yes	Matching live fundus examination with photographs	Live volunteers	Community service projects may enhance short- and long-term ophthalmoscopy skills

Rethinking medical education

As ophthalmoscope use and proficiency declines and many medical students are even discouraged from using the direct ophthalmoscope by their preceptors, what can be done to preserve the teaching of the ocular fundus examination in medical education? Research has shown that proficiency with ocular fundus examination, as with many other skills, decreases without regular reinforcement.¹² Furthermore, there is evidence that most medical students are uncomfortable with direct ophthalmoscopy.¹¹ The preservation of the ocular fundus examination as a skill important to neurologists and primary care physicians will likely require creative solutions that (1) improve the diagnostic yield of ocular fundus examination, (2) reinforce the vital role of ocular fundus examination in patient care, and (3) increase enthusiasm for the ocular fundus examination that some may already view as a dying art. Nonmydriatic fundus photography has demonstrated efficacy in each of these areas and, in concert with other needed reforms in medical school curricula, may provide the needed impetus to restore the ocular fundus examination to its position of decisive aid.

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