

Nonmydriatic Fundus Photography: A Practical Review for the Neurologist

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Manuscript word count: 4148

Number of references: 16

Number of figures: 8

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The authors have no conflict of interest to disclose.

Acknowledgements: Financial support was provided in part by an unrestricted departmental grant (Department of Ophthalmology, Emory University) from Research to Prevent Blindness, Inc., New York, and by the NIH/NEI core grant P30-EY006360 (Department of Ophthalmology, Emory University).

Key Words: Fundus photography, ophthalmoscope, ophthalmology

This is the author's manuscript of the article published in final edited form as:

Mackay, D. D., & Bruce, B. B. (2016). Non-mydriatic fundus photography: a practical review for the neurologist. *Practical Neurology*, 16(5), 343–351. <https://doi.org/10.1136/practneurol-2016-001443>

ABSTRACT

Declining proficiency in direct ophthalmoscopy by non-ophthalmologists has spurred a search for alternative methods of ocular fundus examination. Recent technological advances have improved the ease of use and quality of nonmydriatic fundus photography, increasing its suitability for clinical care. As the availability of this technology continues to improve, neurologists will need to be familiar with its advantages, limitations, and potential applications in the clinical care of patients with neurologic conditions.

INTRODUCTION

Examination of the ocular fundus frequently yields important information that influences the clinical care of patients with neurologic disease. However, difficulty performing ophthalmoscopy has contributed to the relatively recent demise of ophthalmoscopy by non-ophthalmologists.[1] The technical barriers of direct ophthalmoscope use have led to renewed interest in alternative methods of viewing the optic disc, retina, and retinal vessels. Advancements in technology coupled with the continued relevance of the fundoscopic examination have driven interest in nonmydriatic fundus photography as an alternative method of ocular fundus examination. While nonmydriatic fundus photography has been in existence since the 1970s, the technology has only recently advanced to the point of quickly obtaining high-quality fundus photographs, with minimal operator training, that rival the quality of mydriatic fundus cameras. Furthermore, research over the past decade has clarified the utility and potential role of this technology in clinical care. As neurologists are among the most prominent non-ophthalmologists to gather information from the ocular fundus examination for use in clinical care, it is important that neurologists be familiar with nonmydriatic fundus photography, its practical use in clinical settings, and conditions which may be more easily diagnosed or managed with its use.

HOW DOES NONMYDRIATIC FUNDUS PHOTOGRAPHY WORK?

A cooperative patient is seated in front of the fundus camera in a room in which ambient lighting is minimized [Figure 1]. Lighting in the room may be turned off, or in environments that do not allow for adjustment of ambient lighting, an opaque covering supported by a frame may be placed over the head and shoulders of the patient and front of the camera. The patient is instructed to look forward into the camera at a fixation light as infrared fundus videography is used to focus on the region of interest. Many nonmydriatic cameras have software that automatically detects the posterior pole of the eye and takes a photograph when the back of the eye is in focus. Light in the infrared spectrum used during this process does not stimulate pupillary contraction. However, useful photographic images cannot be made from an infrared light source alone, and a flash must still be used for image acquisition. Sensitive image sensors in digital nonmydriatic fundus cameras allows the use of low flash settings, which helps to limit the amount of persistent pupillary constriction following the first image obtained with a flash, although we have shown that the best quality pictures are obtained after an interphotographic interval of about 30-60 seconds.[2] Advancements in digital photography technology have paved the way for additional features that can enhance the ease of use of a nonmydriatic fundus camera, including autofocus and auto-alignment mechanisms, user interface software with task automation, and the ability to print

images, export them to a database or electronic medical record, or share them electronically using a network or internet connection.

WHAT EVIDENCE SUPPORTS THE USE OF NONMYDRIATIC FUNDUS PHOTOGRAPHY IN NON-OPHTHALMOLOGY SETTINGS?

A growing body of research has evaluated the impact of nonmydriatic fundus photography in the emergency department. A cohort of 350 adult patients was enrolled in the Fundus Photography vs. Ophthalmoscopy Trial Outcomes in the Emergency Department (FOTO-ED) study. Inclusion criteria included a chief complaint of headache, acute focal neurologic deficit, acute vision change, or a diastolic blood pressure of at least 120 mmHg. Forty-four of the 350 patients (13%) had a relevant ocular finding on fundus photography (optic disc edema, intraocular hemorrhage, severe hypertensive retinopathy, arterial vascular occlusion, or optic disc pallor). Eleven of the 44 findings were known prior to presentation in the ED, and of the remaining 33 findings, 6 were detected by an ophthalmology consultation, and the other 27 were only identified by fundus photography. Only 5 of the 33 patients with relevant ocular findings not known prior to presentation underwent a funduscopic examination by an ED physician, all of which were documented as normal.[3]

Phase I of the FOTO-ED study focused on the feasibility of nonmydriatic fundus photography in the ED and found that 83% of the 350 patients had a least one eye with a high-quality photograph. Nurse practitioners were given brief training and took the photographs used in the study, with a median image acquisition time of 1.9 minutes per session. Ease and speed of image acquisition were rated highly by the nurse practitioners and patients.[4]

Phase II of the FOTO-ED study focused on diagnostic accuracy and use of nonmydriatic fundus photography in the ED.[5] In this phase, ED physicians were given access to the photographs taken during the ED visit, and were permitted to use them to help influence patient care. Three-hundred fifty four patients were enrolled and 35 (10%) were found to have relevant findings on fundus photographs. ED physicians reviewed the photographs of 238 patients (68%), identified 16 of the 35 relevant findings (46%) using the photographs, and reported the photographs to be helpful for 125 patients (35%).

In a separate study of patients with headache presenting to an academic emergency department, 8.5% (42/497) had abnormal ocular fundus findings detected via nonmydriatic fundus photography. Fourteen of the 41 patients (41%) with abnormal fundus findings who underwent MRI had normal imaging.[6]

In an Australian population, 693 TIA and acute stroke patients underwent pharmacologic pupillary dilation and fundus photography for assessment of retinal microvascular signs (retinopathy, focal arteriolar narrowing, arteriovenous nicking, and an enhanced arteriolar light reflex). All retinal microvascular signs were found to be more prevalent in patients with TIA or stroke than in control subjects, suggesting that fundus photography may provide useful information in the risk stratification of patients with suspected cerebrovascular disease.[7]

WHAT ARE POTENTIAL APPLICATIONS FOR NONMYDRIATIC FUNDUS PHOTOGRAPHY IN NEUROLOGY?

Details of the optic disc and other parts of the ocular fundus are often difficult to discern through undilated pupils. The main source of difficulty in such cases is the technical difficulty of using the ophthalmoscope. When the technical barrier is removed, neurologists, even without specific additional training, are able to use the ocular fundus examination more easily to make informed decisions regarding a patient's care.

Fundus photography in patients with uncontrolled hypertension, headache, vision complaints, or suspicion of cerebrovascular disease may yield important information that influences how the patient is managed. Subtle and sometimes even not-so-subtle fundus abnormalities may be missed with a cursory funduscopic examination in an ambulatory clinic. For example, detection of even mild optic disc edema should prompt an urgent workup to exclude serious underlying causes of elevated intracranial pressure (e.g., cerebral venous thrombosis, tumor, obstructive hydrocephalus) in a patient whose headache may have otherwise been misdiagnosed as primary. The presence of optic disc pallor in a patient with unexplained neurological symptoms may suggest demyelinating disease or its mimics. It could also alert the clinician to obtain an orbital MRI in addition to brain studies to exclude an orbital mass (e.g., an optic nerve sheath meningioma). A patient being seen in clinic for stroke follow-up care with a blood pressure of 220/110 and found to have optic disc edema and retinal hemorrhages and exudates consistent with hypertensive retinopathy may prompt referral of the patient to the emergency department for hypertensive emergency.

Fundus photography has also been used in patients with chronic neurologic conditions, such as cerebrovascular disease and dementia. The brain and retina are similar in their embryological origin and physiological properties, which has inspired research into direct visualization of small vessels of the retina as a surrogate for intracranial small vessels, which cannot be readily visualized *in vivo*. The retinal vasculature can be noninvasively visualized using fundus photography. Indeed, studies have demonstrated a link between retinal vascular changes visualized with fundus photography and stroke and dementia.[8]

Medical Education

Academic medical centers are uniquely positioned to benefit from the acquisition of a nonmydriatic fundus camera, as the benefits may be more easily realized in a large provider group in collaboration with other clinicians and in the training of the next generation of medical professionals. Most medical students have also reported that they prefer to use fundus photographs over direct ophthalmoscopy, and 20% of students in one study reported that their primary reason for not performing an ocular fundus examination during a patient evaluation was discouragement by their preceptor.[9, 10] A photograph allows for clinicians to more easily perform an evaluation of the ocular fundus, to emphasize the importance of the ocular fundus examination in the complete evaluation of many classes of neurologic disease, and to point out key features of the ocular fundus to trainees in the context of an actual patient's evaluation. Challenging cases or findings can easily be shared with other clinicians and

facilitate the diagnostic evaluation.[11] The use of fundus photography in medical education has the potential to restore *enthusiasm* for the ocular fundus examination in future generations of clinicians.

Telemedicine

The rise of telecommunications technology has introduced important telemedicine opportunities, including ocular fundus photography interpretation.[12] The use of telemedicine in acute stroke has increased dramatically in recent years, despite significant regulatory and other barriers to its implementation. The success of “telestroke” evaluations has been founded upon rapid access to a specialist in areas where the specialist is not readily physically available. Rapid fundus photograph interpretation through a tele-ophthalmology consultation may become standardized in the future. In the meantime, fundus photographs may be shared with other clinicians and colleagues electronically to help facilitate triage decisions.

ABNORMALITIES OF THE OCULAR FUNDUS REQUIRING URGENT EVALUATION

All patients presenting to a neurologist with a visual complaint should be seen by an eye care specialist as soon as possible. Furthermore, the neurologist is likely to encounter the following ocular fundus abnormalities relatively frequently, all of which generally indicate the need of an emergent or expedited work-up.

Optic Disc Edema

Optic disc edema can be difficult to see with a direct ophthalmoscope in some patients and a fundus photograph may be helpful. A fundus photograph may not be able to clarify whether a patient has very subtle optic disc edema, but is useful in looking for other funduscopic signs of optic disc edema. These signs include blurring of the optic disc edges, filling in of the optic cup, peripapillary folds, obscuration of vessels as they cross the optic disc margin, peripapillary retinal hemorrhages, optic nerve head hyperemia, and venous congestion [Figure 2].[13] Photographs can also be very useful in distinguishing pseudopapilledema from true optic disc edema. For example, visualization of multifocal, irregular, globules (sometimes described as tapioca-like) within the optic nerve head are diagnostic for optic nerve head drusen [Figure 3].

Optic Disc Pallor

A normal optic disc is typically pink/orange in color. An abnormally white optic disc appearance is referred to as optic disc pallor, which is a sign of damage to the optic nerve and takes at least 4-6 weeks to develop after an injury. The pallor may be subtle, and assessment of optic disc color is subjective and can be influenced by photographic exposure, adding to the difficulty in detecting optic disc pallor. In unilateral cases, pallor may be more easily detected by comparing fundus photographs between the two eyes [Figure 4]. Details of the pallor may also be helpful, such as definite pallor limited to the superior or inferior portion of the optic disc, as seen patients with a history of nonarteritic anterior ischemic optic neuropathy. Optic disc pallor can provide additional evidence for a history of optic neuritis in a patient with suspected demyelinating disease. Moderate to severe generalized pallor is accompanied by a

noticeable lack of small vessels on the temporal part of the optic disc. Thus, abnormal optic disc color is not the only abnormality to suggest optic disc pallor.

Central or Branch Retinal Artery Occlusion

Patients with central retinal artery occlusion (CRAO) classically exhibit a macular cherry red spot with an otherwise pale retina, as the clinician can see the intact choroidal blood supply through the central (thinnest) part of the macula [Figure 5]. There may also be interruptions of the blood column within the retinal arteries giving the appearance of train cars, so-called “box-carring”. In 4-6 weeks, the retinal whitening resolves and the optic disc may appear pale with attenuation of the retinal arterioles. An acute branch retinal artery occlusion causes whitening of the portion of the retina supplied only by the affected vessel. Like a CRAO, the whitening may only last several weeks and the only clue may be attenuated arterioles within the affected area. Counterintuitively, widespread abnormalities such as the retinal whitening from a CRAO can be difficult to detect with a direct ophthalmoscope because the narrow field of view makes it difficult to compare affected and unaffected parts of the retina.

Central or Branch Retinal Vein Occlusion

Central retinal vein occlusion is typically associated with extensive flame-shaped hemorrhages throughout the ocular fundus, dilated and tortuous retinal veins, and may include optic disc edema. Branch retinal vein occlusion involves the same signs restricted to the vascular drainage territory of the affected vein branch [Figure 6, occlusion at double arrow]. Branch occlusions typically occur at arteriovenous crossings, as seen in this case. Risk factors include increasing age, hypertension, diabetes, hyperlipidemia, cigarette smoking, and thrombophilia.[14]

Severe Hypertensive Retinopathy

Features of both mild and severe hypertensive retinopathy may be more easily detected with fundus photography than direct ophthalmoscopy. Hypertensive retinopathy is most commonly mild and characterized by arteriolar narrowing as one of the earliest signs. Optic disc edema is a feature of very severe hypertensive retinopathy, and can usually be differentiated from other causes of optic disc edema by the presence of retinal hemorrhages distant from the optic disc and exudates that indicate breakdown of the blood-retina barrier. Cotton wool spots (areas of retinal infarction) may also be seen in severe cases.

Intraretinal hemorrhages

Intraretinal hemorrhages are a sign of blood vessel damage, most often from hypertension, but their significance is not completely elucidated. A trial of 497 patients presenting to a tertiary care academic emergency department with headache found 42 of the patients had ocular fundus abnormalities, 15 of which had isolated retinal hemorrhages, presumably related to hypertension. Another 6 patients had grade III/IV hypertensive retinopathy, suggesting that half of the patients (21/42) with abnormal ocular fundus findings in this headache population were related to hypertension.

INTERPRETATION OF FUNDUS PHOTOGRAPHS BY NEUROLOGISTS

Non-ophthalmologists are likely to interpret ocular fundus abnormalities more easily using photographs than with direct ophthalmoscopy. Nevertheless, instruction in the approach to the ocular fundus examination via photographs may be useful for neurologists using fundus photography in clinical care. While no one approach is universally advocated, having a systematic and organized approach to the examination of the ocular fundus in a photograph has the potential to improve the accuracy of interpretation. Nevertheless, it cannot be overemphasized that *all patients with vision loss* must also be evaluated by an ophthalmologist, regardless of ocular fundus findings.

As with any other diagnostic test, fundus photographs are best interpreted in the context of a patient's clinical history and examination findings. Such context is often essential to know what findings may be incidental or inconsequential, and what others may contribute valuable information to the patient's evaluation and inform further management decisions.[15]

As a generic approach to the ocular fundus examination in a photograph, one may arbitrarily divide the ocular fundus into regions, with prompts the clinician to look for specific findings in each region. Determining which eye you are viewing can be facilitated by remembering that the optic disc is closest to the nose. Therefore, in a properly centered photograph in which you see the macula and the optic disc, you will find the optic disc to the left side of the photograph in the left eye, and to the right side in the right eye.

Optic Disc

Key features of the optic disc to be evaluated during a fundus examination include the disc color, sharpness of margins, and the cup-to-disc ratio. In a photograph, the cup-to-disc ratio can be obvious, or difficult to discern, depending on the patient. An enlarged cup-to-disc ratio may be normal and physiologic, or associated with glaucoma. The temporal portion of the optic disc is normally slightly more pale than the nasal portion, but excessive or generalized optic disc pallor can be a sign of an optic neuropathy [Figure 4]. In the setting of a relative afferent pupillary defect, unilateral or asymmetric optic disc pallor confirms damage to the optic nerve that began at least 4-6 weeks prior. Blurring of the optic disc margins is a sign of optic disc edema, and the differential diagnosis is influenced by whether the edema is segmental or generalized, and unilateral or bilateral.

Macula

The macula is normally found temporal and slightly inferior to the optic disc and contains densely-packed cone photoreceptors that are essential for high-acuity color central vision. The foveal light reflex is a normal reflection of light from the thin retinal layers at the fovea and can sometimes be seen in fundus photographs. A decreased foveal light reflex in one eye associated with a decrease in visual acuity in that eye can indicate a foveal abnormality, such as macular edema. Neuroretinitis, caused by inflammation of the retina and optic disc, is primarily recognized by an associated macular-star pattern of exudates, often with optic disc edema [Figure 7]. Other macular abnormalities such as hemorrhage are generally more easily seen with fundus photographs than via direct ophthalmoscopy.

Retinal Vessels

Dilated retinal vessels may be seen in papilledema or in occlusive disorders of the retinal veins, such as a central or branch retinal vein occlusion. Arteriovenous nicking may be seen in patients with chronic hypertension, in which a hard atherosclerotic arteriole compresses a retinal vein, resulting in a focal change in the contour of the vein and a “nicked” appearance [Figure 6, arrows]. Patients with a history of transient monocular vision disturbance should be examined for a Hollenhorst plaque, which is a sign of cholesterol embolization from a proximal atherosclerotic source [Figure 8].

Mid-Peripheral Retina

Retinal abnormalities such as hemorrhages, exudates, and microaneurysms are often difficult to detect with a direct ophthalmoscope and may be more easily detected in a fundus photograph. Hemorrhages and exudates distant from the optic disc can be seen in conditions such as hypertensive retinopathy and diabetic retinopathy and would not be expected in other conditions, such as papilledema from raised intracranial pressure. Microaneurysms are seen as small dots of blood in the retina due to outpouching of retinal capillaries, and can be seen in diabetic retinopathy.

Other Normal Findings

A highly reflective layer, sometimes surrounding the optic nerve and macula, may be visible in photographs in younger patients. This is the inner limiting membrane, and is a normal finding that may confuse some non-ophthalmologists. Patients with lightly pigmented skin can have a distinctive ocular fundus appearance with “tangles” of orange streaks behind the retinal vessels, which are the choroidal vessels, and are a normal finding called a “blonde” fundus. Conversely, patients with more darkly pigmented skin tend to have a more “tigroid” appearance that resembles tiger stripes, which represents the choroidal vessels against a background of darker pigments, which is also a normal finding.

Artifacts

Artifacts are common in fundus photography and may result from incorrect patient-camera orientation, excessively small pupils, camera lens debris, or other causes. A faded whitish area with a gradient from the edge of the photograph may be a sign of artifact from the pupil border in patients with smaller pupils. Other cloudy artifacts may be seen, and can be confirmed as artifactual by comparing with photographs from the same eye in a slightly different position (in which the artifact is seen in a slightly different location), or from the contralateral eye.

WHAT ARE ADVANTAGES AND DISADVANTAGES OF NONMYDRIATIC FUNDUS PHOTOGRAPHY IN NEUROLOGY?

Strengths

As with any diagnostic tool, an accurate understanding of the strengths and limitations of nonmydriatic fundus photography can help clinicians know when fundus photographs may be useful. One of the main advantages of nonmydriatic fundus photography is convenience. Obtaining images from a fundus

camera in the emergency department or an outpatient clinic is relatively fast and easy, with the median time of image acquisition in Phase I of the FOTO-ED study being just 1.9 minutes.[4] As handheld nonmydriatic fundus camera technology improves and becomes more commonplace, it will be very helpful to refrain from dilating the pupils of critical care patients with intracranial pathology in whom following a pupillary examination is important, as most would not otherwise be sufficiently cooperative for fundus photography. Clinicians and students also find fundus photograph interpretation easier than using a direct ophthalmoscope through an undilated pupil.[5, 9, 10] The quality of the images is also very good in most patients, rivaling the quality of mydriatic fundus cameras. The resolution of the images typically also allows for digital zoom to appreciate finer details of the ocular fundus. As was also demonstrated in Phase I of the FOTO-ED study, nurse practitioners who operated the fundus camera required minimal training. The images are also available to share with others for educational purposes, to facilitate triage decisions, and to enhance medical education.[11, 16] The photographs may also serve as a very precise form of documentation, which may be helpful for future clinic visits and medicolegal cases. For the purposes of a neurology evaluation, nonmydriatic fundus photography allows for a detailed assessment of the ocular fundus, without pupillary dilation.

Limitations

One disadvantage or limitation of nonmydriatic fundus photography is the cost of equipment, which can be around \$25,000 to \$30,000 depending on the model. However, prices are likely to decline with more widespread adoption of the technology. Also, current nonmydriatic cameras require a patient to be alert and cooperative, sit still, and be able to follow simple commands, which applies to most outpatients, but not all. There are several models of handheld nonmydriatic cameras which may be useful for uncooperative patients in acute care settings, such as the intensive care unit, although the quality of images is currently inferior to stationary desktop models and the devices are considerably more difficult to use. Devices that attach to smartphones to take fundus photographs have become more popular in recent years, but they still require pupillary dilation, which limits their use among neurologists. Nonmydriatic fundus photographs also do not provide a dynamic view of the ocular fundus, meaning that the evaluation of spontaneous venous pulsations, subtle abnormalities of visual fixation such as low amplitude nystagmus, or the rare occurrence of tracking a moving retinal embolus remain reserved for a live funduscopic view via an ophthalmoscope or the occasional camera with video capabilities.

BOX 1. CASE STUDY

A 40 year-old woman presented for evaluation of probable idiopathic intracranial hypertension (IIH). She has a history of refractory hypertension and headaches. She had several months of episodic vision disturbances with lightheadedness and worsening of headaches. An MRI of the brain showed an empty sella turcica. A neurologist diagnosed her with IIH, without a lumbar puncture at that time. Several months later, she noticed a dark spot in the vision of her right eye. Her neurologist then arranged for a lumbar puncture, which showed an opening pressure of 22 cm of water with normal CSF. "Mild blurring

of the disk margins” was documented by the neurologist and she was started on acetazolamide for a presumed vision disturbance related to IIH.

On examination, BMI was 43.1 kg/m² and BP was initially 216/143 mm/hg. Visual acuity was 20/200 in the right eye and 20/20 in the left eye. There was no relative afferent pupillary defect. Confrontation visual fields showed decreased vision inferonasally in the right eye and were full in the left eye.

Fundus photographs showed pink, sharp optic discs with no disc edema, but the right eye retina showed extensive retinal hemorrhages localized to the superotemporal macula with scattered flame-shaped hemorrhages and cotton wool spots in the same localized area, in a pattern consistent with a branch retinal vein occlusion [Figure 6].

IIH had been misdiagnosed in this case, partially because of difficulty performing funduscopy. It was presumed that her vision disturbance was from IIH, although a fundus photograph clearly showed significant retinal abnormalities without optic disc edema, that would have been easily discerned by a non-ophthalmologist assisted by a photograph. A fundus photograph performed by the referring neurologist would have localized the abnormality, which was not consistent with IIH, prevented unnecessary invasive testing, and facilitated referral to an ophthalmologist for evaluation and management.

CONCLUSIONS

The importance of the ocular fundus examination persists, despite the demise of direct ophthalmoscopy seen in recent decades. The nonmydriatic fundus camera is an alternative tool that bypasses the technical difficulty of the direct ophthalmoscope and makes the ocular fundus examination more accessible. A combination of clinician discomfort with the use of a direct ophthalmoscope, persistent relevance of the ocular fundus examination, and increasing availability of nonmydriatic fundus cameras in clinical care is creating momentum for more widespread adoption of nonmydriatic fundus photography technology. Neurologists are poised to benefit from this momentum and should be familiar with the application of nonmydriatic fundus photography in clinical care.

KEY POINTS

- Nonmydriatic fundus photography is an effective alternative to direct ophthalmoscopy for examination of the ocular fundus in non-ophthalmology settings
- Even without additional training, abnormalities of the ocular fundus are easier to detect and interpret with photographs than with direct ophthalmoscopy
- As the availability of nonmydriatic fundus photography increases, neurologists will need to be familiar with its advantages and limitations in clinical care

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FIGURE LEGENDS

Figure 1. Typical configuration of nonmydriatic fundus camera. The patient is seated in a chair opposite the fundus camera. A computer is attached to the device, and runs software that automates portions of the image acquisition process and allows for digital image review, storage, and distribution.

Figure 2. Papilledema in a patient with idiopathic intracranial hypertension. This photograph exhibits several key findings that, in combination, are quite specific for true optic disc edema, including peripapillary retinal folds (concentric arcs identified by dashed arrows), partial optic disc vessel obscuration (double arrow), and a small focal hemorrhage (arrow).

Figure 3. Prominent optic nerve head drusen. Irregular, tapioca-like globules can be seen in this patient's optic nerve heads: right eye (A) and left eye (B). Less obvious examples require careful examination of the optic nerve head to screen for this not uncommon mimic of optic disc edema.

Figure 4. Unilateral optic disc pallor. The right optic disc (A) is normal in color. The left optic disc (B) exhibits subtle pallor, particularly temporally (right side of the disc in the photograph). Comparing the optic discs from each eye in photographs is a valuable tool in the detection of unilateral optic disc pallor.

Figure 5. Central retinal artery occlusion (CRAO). Note the macular cherry red spot (arrow) with an otherwise pale retina, as the clinician can see the intact choroidal blood supply though the central (thinnest) part of the macula.

Figure 6. Branch retinal vein occlusion (BRVO). Note the presence of hemorrhages, cotton wool spots, and tortuous and dilated veins distal to the site of BRVO (double arrow) involving the superotemporal macula. Arteriovenous nicking is also seen as a result of uncontrolled systemic hypertension (arrows).

Figure 7. Neuroretinitis. This photograph depicts optic disc pallor for optic nerve damage as well as yellowish exudates in the peripapillary retina and macula that are radially oriented in a "star" pattern, consistent with neuroretinitis. Optic disc edema may be the first sign, followed days to weeks later by appearance of retinal exudates suggestive of retinal inflammation.

Figure 8. Hollenhorst plaque. A cholesterol embolism (Hollenhorst plaque, arrow) is visible in a superior retinal arteriole, which came from a proximal atherosclerotic source.