Ultra-Widefield Fundus Autofluorescence Imaging:

An Ophthalmic Photographer's Perspective

Recent technological advances in fundus autofluorescence and the advent of ultra-widefield imaging are providing insights into retinal physiology and pathophysiology.

By Olivia Rainey, OCT-C

Both ultra-widefield (UWF) fundus imaging and fundus autofluorescence (FAF) have significantly improved our understanding of retinal diseases. FAF is useful in determining whether a condition is latent or progressing to healthier areas of the retina, and ultra-widefield fundus autofluorescence (UWF FAF) imaging has provided new opportunities to observe and document changes in the far periphery.

In one study, abnormal FAF patterns were identified outside the central 30 degrees in nearly 70% of patients seen at a tertiary retina clinic; the patients had age-related macular degeneration (AMD), central serous retinopathy, retinal dystrophy, inflammatory disorders, ocular tumors, and retinal vascular disease.[1] Additional research suggests that FAF findings may represent an independent measure of disease stage and activity in early AMD.[2]

A nonmydriatic fundus camera that captures UWF FAF can complement other imaging modalities commonly used in the clinic and can be learned quickly. FAF is noninvasive and produces minimal discomfort in the patient. This allows for efficient and reliable documentation of retinal diseases.

(1) WRONG LATERALITY. *UWF FAF image of the left eye that had the wrong laterality selected when capturing the image, causing the treated choroidal melanoma to become elongated and unreliable for comparison.*

Fundus Autofluorescence

FAF takes advantage of the autofluorescent properties in lipofuscin to identify its absence or accumulation, which can be an indicator of the metabolic state and overall health of the retinal pigment epithelium (RPE).

Hypoautofluorescence. Dark areas on FAF typically mean that no lipofuscin is present because the RPE cells have died, indicating vision loss or scotomas (Fig. 2), or that the signal is being absorbed because of interference by blood, pigment, or another blocking artifact. Common findings associated with hypoautofluorescence include RPE atrophy, new hemorrhages, exudative lesions, laser scarring, dense hyperpigmentation, forms of hard drusen, and vitreous opacities.

Hyperautofluorescence. Areas that appear hyperautofluorescent, or brighter than the normal gray background autofluorescence, reveal an excess accumulation of lipofuscin and may represent increased metabolic activity of the RPE.

For example, in nonexudative AMD, hyperautofluorescence can surround hypoautofluorescent lesions, which may indicate that these lesions are progressively enlarging; this is often undetectable on fundus examination or other forms of imaging (Fig. 3). Common pathology or characteristics associated with hyperautofluorescence include yellow lesions, bull's-eye maculopathy, older hemorrhages, soft drusen, and demarcation lines.

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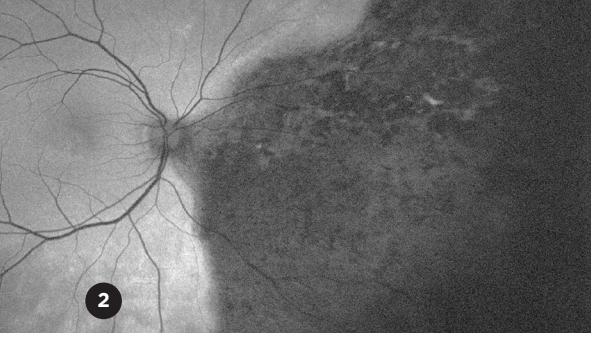
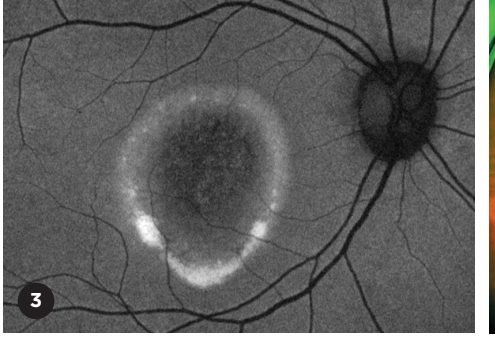
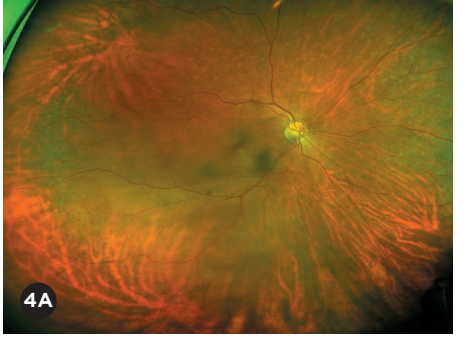
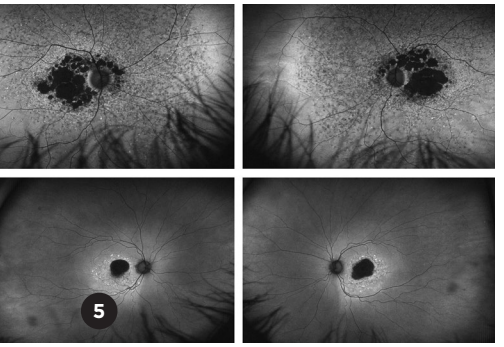
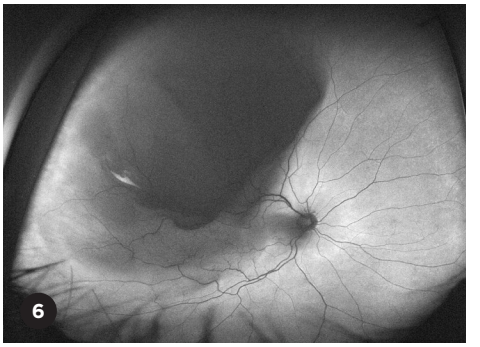
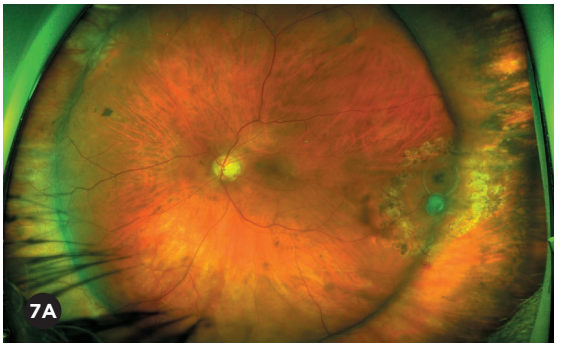












Age-Related Pigmentary Changes

An Age-Related Eye Disease Study on peripheral retinal changes associated with AMD concluded that peripheral retinal changes are more prevalent than previously thought.[3] UWF FAF reveals that there can be significant age-related pigmentary changes in the periphery, and these may look similar to changes that take place in the posterior pole. UWF FAF has shown a loss of melanin granules, peripheral reticular pigmentary changes, cobblestone degeneration, and formation of pseudodrusen in some patients when it may not have been as clearly visible with examination or color fundus photography (Fig. 4).

Inherited Retinal Disease

Because each inherited retinal disease (IRD) can present differently, a physician's ability to recognize the characteristics of each is key to early diagnosis. UWF FAF is particularly helpful in evaluating IRD since the extent of abnormal FAF typically correlates with the results of visual field testing and electroretinography.

The ability to reliably visualize, document, and longitudinally study the extent of IRD has been enhanced through UWF imaging, which can capture most of the periphery for more accurate and complete documentation (Fig. 5).

Retinal Detachment

UWF FAF reveals abnormalities in retinal detachments (RDs) that allow excellent demarcation of the extent of the RDs and assist in both preoperative characterization of the detachment and postoperative counseling.[4] UWF FAF of an RD may reveal hypoautofluorescence in the area of detached retina, which may be due to subretinal fluid blocking the autofluorescent signal (Fig. 6). A leading hyperautofluorescent edge may be present at the margin of the RD. The collection of fluorophores from the photoreceptor outer segments, and/or RPE cells with their increased metabolic activity, may result from the stress at the border of the attached and detached retina (Fig. 7).

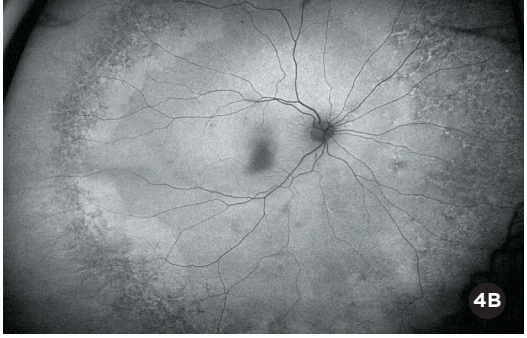
Choroidal Melanoma and Nevus

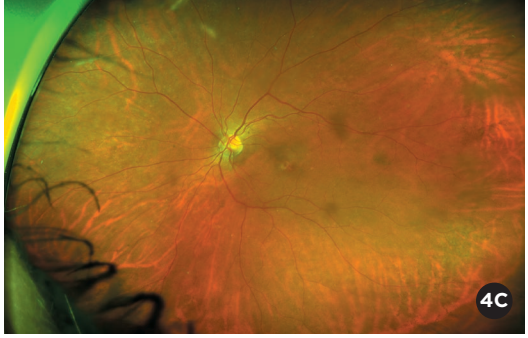
It is common to see abnormal FAF within choroidal melanomas—unlike choroidal nevi, which are less likely to have abnormal FAF. If orange pigment or subretinal fluid is present in choroidal melanoma and nevi, an increase of hyperautofluorescence may be an indication of lesion growth. In large, pigmented choroidal melanomas, there may also be areas of central hypo- or hyperautofluorescence corresponding to RPE atrophy or disruption, respectively.

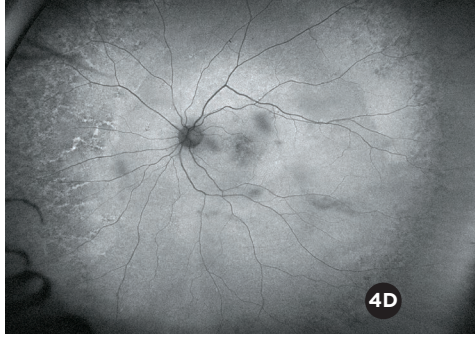
Drawbacks of Diagnosing With UWF FAF: Artifacts

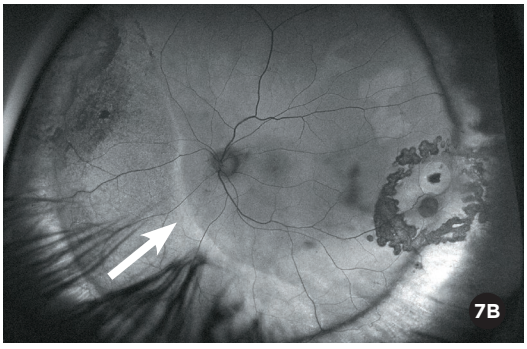
Although UWF FAF is excellent for providing unique insights into many conditions, factors other than the condition itself can affect the clarity and accuracy of UWF FAF images. Should you decide to implement UWF FAF, to be successful, you must be aware that artifacts are possible with any of the UWF systems. FAF imaging is commercially available from companies such as Canon, Heidelberg Engineering, Nidek, Optos, Topcon, and Zeiss. In our clinic, I use the Optos UWF FAF and have observed the following:

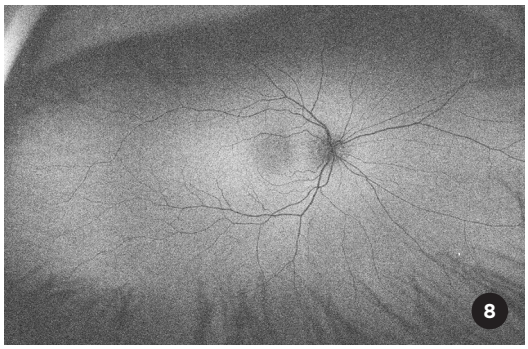
- The physical structures of the eye can block the full view of the periphery. For instance, if patients are not opening their eyes wide enough, if they

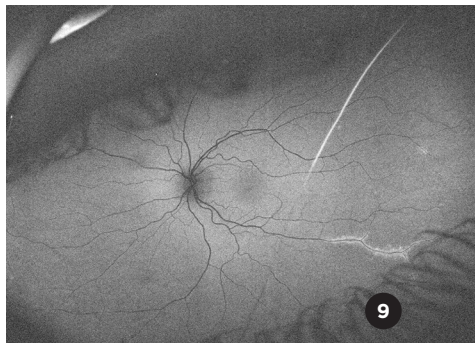












have drooping lids, or if they are light sensitive, the view may be obstructed. I hold patients' eyelids and lashes and instruct them to blink then hold wide before imaging to prevent obscuration of the periphery (Fig. 8).

- The automatic focus usually can get a clear picture. However, significantly elevated lesions may appear slightly blurred. Pathologies within the vitreous can also be difficult to image clearly.
- The shape of the ellipsoid rotating mirror inside the camera can cause distortion of the peripheral fields. In addition, the spherical nature of the globe can make pathology appear elongated and prevent accurate measurement of retinal lesions on the image (Fig. 1).
- Most ophthalmic imaging systems will automatically detect which eye is imaged, yet with the Optos, the technician must select the laterality of the eye; if the wrong eye is selected, the image may appear distorted.
- Various artifacts and opacities such as hair, floaters, haze from inflammation, and hemorrhages can block or interrupt the strong signal necessary for a clear image (Fig. 9).

1 Heussen FM et al. *Invest Ophthalmol Vis Sci.* 2012;53(10):6526-6531.

2 Holz FG et al. Age-related macular degeneration I—early manifestation. In: Holz FG, Schmitz-Valckenberg S, Spaide RF, and Bird AC, eds. *Atlas of Fundus Autofluorescence Imaging.* New York: Springer; 2007:133-147.

3 Domalpally A et al. *Ophthalmology.* 2017;124(4):479-487.

4 Witmer M et al. *Eye* (Lond). 2012;26:1209-1216.

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(2) LACK OF LIPOFUSCIN. *UWF FAF image of unspecified retinitis of the right eye, revealing a large area of hypoautofluorescence within the periphery.*

(3) LESION ENLARGING. *UWF FAF images of Best disease showing bilateral hyperautofluorescence, with central hypoautofluorescence affecting the macula.*

(4A-4D) UWF FAF ADVANTAGE. *UWF bilateral series of a patient with macular degeneration, showing how UWF FAF reveals significant peripheral reticular changes, whereas in the pseudocolor image, these changes are much less noticeable.*

(5) STARGARDT DISEASE. *UWF FAF bilateral images of Stargardt disease, showing how the same disease can present itself very differently in different patients, yet still have similar characteristics like hypoautofluorescent central lesions with hyperautofluorescent flecks in the periphery.*

(6) RETINAL DETACHMENT. *The UWF FAF image clearly shows the retinal tear in the right eye, causing a macula-off retinal detachment. The superotemporal retina affected by the retinal detachment is very dark and has clearly progressed into the posterior pole.*

(7A, 7B) RD REPAIR. *UWF pseudocolor and UWF FAF images of a retinal detachment repair of the left eye. There is a clear hyperfluorescent leading-edge line within the nasal quadrant of the retina, extending from the inferior to superior retina.*

(8) ARTIFACTS. *UWF FAF image of the right eye with eyelid and eyelash artifact.*

(9) HAIR ARTIFACT. *UWF FAF image with a very noticeable hair artifact in the left eye. However, the peripheral inferior vessel sheathing can still be seen.*