

Fundus Autofluorescence Imaging

The Canon CX-1 Hybrid Retinal Camera has proved useful in community-based screenings for early detection of vision-threatening diseases.

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The role of community-based screenings for vision-threatening diseases (VTDs) in the detection of cataracts, age-related macular degeneration, diabetic retinopathy, and glaucoma is increasing with the aging of baby boomers, as well as the changing realities of world economies. With unemployment passing the 10% mark in the United States and continuing loss of health insurance, along with increasing prevalences of obesity, hypertension, and poor nutritional habits in both the pediatric and adult populations, the incidence of VTDs is expected to increase. Moreover, VTDs often remain undetected until the late stages of disease, with resultant loss of vision. Fundus autofluorescence (FAF) imaging is a noninvasive procedure that targets the retinal pigment epithelial cells (RPE), among others, and allows the screener to achieve a higher detection rate for changes associated with VTDs in affected subjects. Better detection rates, in turn, translate to more timely triage and clinical referral.

FAF imaging highlights lipofuscin, a biomarker of cellular aging and oxidative cell damage. It forms as an accumulation of lipophilic lysosomal debris from unsaturated fatty acid oxidation.¹ Histologic studies in donor eyes have shown increased accumulation of lipofuscin in the RPE with age, poor diet, and in certain retinal diseases.²⁻⁴ It is a byproduct of phagocytosed photoreceptor outer segments.⁵ Lipofuscin buildup compromises RPE function and is involved in the pathogenesis of various retinal disorders.^{6,7}



Figure 1. The Canon CX-1 hybrid retinal camera is a 45/50°, dual nonmydriatic and mydriatic retinal camera with full head tilt and swing. Imaging capabilities include color imaging, red-free imaging (green optical filter for enhanced diabetic retinopathy viewing), cobalt blue illumination (cobalt blue optical filter for optimum nerve fiber layer viewing), fluorescein angiography, and fundus autofluorescence (near infrared).



Figure 2. Image of the anterior segment captured using a plus-diopter, small-pupil setting, and 2x cropping software-driven magnification.

METHODOLOGY

All subjects who took part in VTD imaging sessions signed an institutional review board-approved consent form before their participation. All subjects were previously evaluated by a board-certified retina specialist and underwent follow-up examinations. A Canon CX-1 hybrid retinal camera (Canon Inc, Tokyo, Japan) providing 15.1-megapixel resolution (Figure 1), with 45° nonmydriatic mode (requiring 3.8-mm pupillary dilation) and 50-degree mydriatic mode, was used for ocular imaging. The CX-1 allows anterior segment imaging (cataract detection) by using a plus-diopter setting and 2x function (Figure 2), color retinal imaging (Figures 3 and 4A), red-free imaging (Figure 4B), cobalt blue imaging for nerve fiber layer assessment, and FAF imaging (Figure 4C) with an exciter filter (530-580 nm) and a near infrared barrier filter (640 nm). FAF images were analyzed for hypofluorescence or hyperautofluores-



Figure 3. Diabetic retinopathy montage (DualAlign, LLC, Clifton Park, NY) with four 45° color images, status post pan-retinal photocoagulation. Paramacular/macular hemorrhages, status post focal laser treatment. Suggestive of glaucoma on the basis of increased cup-to-disc ratio.

cence as an indicator of lipofuscin accumulation and retinal health. The CX-1 has fluorescein angiographic capabilities, but these were not used in our screening protocol, as we focused on noninvasive procedures only.

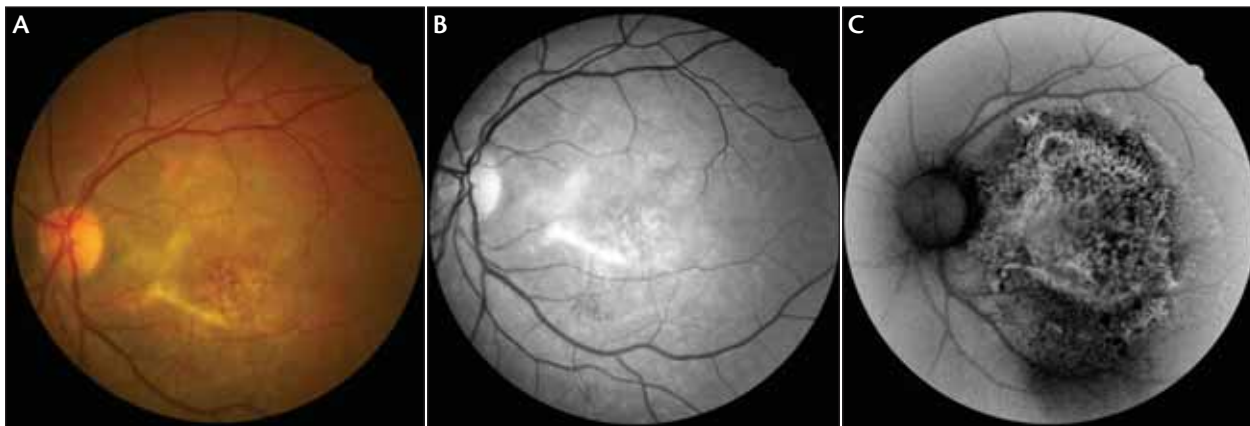


Figure 4. Color fundus image showing age-related macular degeneration (A). Red-free, optically produced image showing age-related macular degeneration (B). Fundus autofluorescence image showing area of hyperfluorescence in the macula and posterior pole in age-related macular degeneration (C).



Figure 5. Color montage (DualAlign, LLC) composed of five 45° images. History of blunt trauma with choroidal rupture, retinal atrophy, fibrosis, and optic nerve pallor (A). Fundus autofluorescence montage composed of five 45° images. History of blunt trauma with choroidal rupture, retinal atrophy, and fibrosis showing large areas of hypofluorescence (B).

DISCUSSION

Fundus autofluorescence provides an index of RPE lipofuscin⁸ that can be used for (1) enhancing our understanding of retinal disease pathogenesis by tracking temporal changes in lipofuscin deposition and distribution; (2) determining diagnosis of certain retinal disorders before detectable functional loss; (3) identifying risk factors that may affect lipofuscin accumulation in the fundus; (4) differentiating diseases with similar lipofuscin signatures; (5) visualizing RPE damage

Early detection of VTDs along with lifestyle changes and early intervention can improve outcomes of certain VTDs such as those found in diabetes.

(Figures 5A and B) and subsequent cell migration and proliferation, such as after laser treatment for diabetic retinopathy or macular edema;⁹ and (6) differentiating choroidal melanocytic lesions and studying the effects of treatment.¹⁰

CONCLUSION

The spectral sensitivity range of FAF was detected in the area of the RPE and deeper layers.

We have illustrated the usefulness of this technology in diabetic retinopathy, age-related macular degeneration, and ocular trauma. Early detection of VTDs along with lifestyle changes and timely intervention can improve outcomes of certain VTDs such as diabetic retinopathy. In community-based screenings, FAF can improve early detection of VTDs and provide timely referral of patients for treatment of subtle retinal changes that are not well detected with conventional color or red-free retinal imaging. ■

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