Multispectral Imaging: A Revolution in Retinal Diagnosis and Health Assessment

The ability to image the retinal pigment epithelium provides clinicians a novel way to examine the retina.

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The Retinal Health Assessment (RHA, Annidis Health Systems Corp.) is a multispectral imaging (MSI) device that is useful for the early detection of optic nerve and retinal disease. It features advanced imaging modalities that allow users to differentiate and follow a wide variety of complex eye conditions and diseases. This instrument differs from other retinal imaging in that it employs an extensive range of discreet monochromatic light sources to create a series of en face fundus spectral sections throughout the thickness of the retina and choroid. The images are captured in a few seconds and reveal detailed views of a variety of retinal and choroidal structures, allowing for very early diagnosis and easier differentiation of occult or overlapping pathology.

Images can be captured in the screening mode through anatomically small or undilated pupils or in the full diagnostic mode through small or dilated pupils. Image quality is maintained through small pupils using a low-light xenon flash that is applied to the retina during image acquisition. The screening mode is designed to survey the deep retina for early pathological change during routine examinations or as part of a pretesting workup (Figure 1). The diagnostic mode provides clinicians the ability to differentiate and follow pathology. The diagnostic modality provides additional images captured through a broader spectral range (Figure 2).

One of the instrument’s biggest advantages is that it can provide a high-resolution, en face view of the retinal pigment epithelium (RPE) and the deep retinal structures not commonly seen with conventional noninvasive imaging techniques or ophthalmoscopy. The RPE has a high metabolic rate and is considered to be one of the...
The use of multiple spectrums of light allows the RHA to capture images of retinal and choroidal structures. In many cases, the finite imaging possible with the RHA can help clinicians detect pathologies early in the disease course—and early-stage disease detection may permit clinicians to initiate interventions that may spare patients their vision.

Following are some case examples of how RHA imaging can have a tremendous impact on clinical decision making.

**Figure 1.** RPE atrophy is easily revealed by MSI in early AMD.

**Figure 2.** Atrophic and later stages of AMD can be followed at the level of the RPE and choroid in order to survey for exudative changes. The long infrared map defines areas of RPE atrophy. The oxy map will reveal areas of exudative leakage containing serum oxyhemoglobin. In this case, only intact vasculature is appreciated.

**Figure 3.** Detection of retinal pathology associated with lipofuscin accumulation. The RHA uses long-wavelength fundus autofluorescence to detect very early lipofuscin accumulation.

**Figure 4.** The RHA employs green, amber, and yellow wavelengths of light to create highly visible features of diabetic retinopathy. Preproliferative vascular anomalies are, thus, easily distinguished.

**Figure 5.** The RHA provides the superficial, deep, and vascular enhancing images that are helpful for distinguishing benign features of choroidal lesions, notably nevi.

**Figure 6.** Oximetry mapping with the RHA may help distinguish retinal vascular collaterals from neovascularization.

**Figure 7.** RHA oximetry reveals areas of retinal and optic nerve hyper- and hypoperfusion.
most important structures in the maintenance of retinal health. Visualization, early detection, and monitoring of changes in the RPE enhances a clinician’s ability to educate, counsel, and devise treatment for patients.

The RHA does more than image the RPE, however. The instrument is capable of performing an in-depth retinal health screening and a comprehensive diagnostic analysis that allows for the detection and differentiation of a wide variety of retinal, retinal vascular, choroidal vascular, and optic nerve disorders.

**FUNCTIONALITY: HOW DOES THE INSTRUMENT WORK?**

MSI entails the use of an extensive range of discrete monochromatic light sources, with each one capable of penetrating or fluorescing different light-absorbing species or chromophores throughout the layers of the retina and choroid (Figure 3). For example, long wavelength light (beyond 600 nm) is used to spectrally reveal melanin, and a slightly longer wavelength is used to reveal lipofuscin. The instrument also provides differential views of the superficial retina, the nerve fiber layer, RPE (Figure 4), sub-RPE, choroid, and the retinal and choroidal vasculature by using individual and combination wavelengths ranging from 533 to 850 nanometers that are selectively absorbed by hemoglobin, melanin, and macular pigments (xanthophyles).

**THE CLINICAL VALUE OF RPE VISUALIZATION**

Visualization of the RPE structure is essential in primary care screening because it is the clinical origin point of many retinal diseases. For example, the diagnosis of age-related macular degeneration (AMD) depends on signs in the retina (drusen is typically the hallmark of the early disease stages) regardless of visual acuity. Additionally, drusen can represent a late-stage finding of RPE pathology, so direct examination of the RPE is critical for both early detection and the classification of AMD. Moreover, research such as the Rotterdam Age Related Maculopathy Study shows that the combination of RPE melanin disruptions combined with the appearance of drusen are associated with a 5-fold increase in the risk of developing exudative AMD over 5 years.

In a primary eye care setting, visualization of the RPE (both melanin and lipofuscin) may provide clinicians with a greater capacity to monitor early changes in this metabolically active structure of the eye. Based on findings from imaging the RPE and choroid, clinicians may choose to counsel patients earlier or more aggressively regarding diet and modifiable risk factors. More importantly, as genetic testing, nutriceutical, pharmaceutical, and ophthalmic lens technology research continues to reveal therapeutic treatments for RPE disease, visualizing the RPE independent of other structures for the signs of early changes might become routine standard of care in targeted populations.

MSI may also have applications for monitoring conditions that affect the melanin pigment in the RPE, including:

- acquired and hereditary retinal diseases and lesions with pathogenesis rooted in melanin dysfunction or proliferation (e.g., nevi, melanoma, congenital hypertrophy of the RPE, retinitis pigmentosa, neurofibromatosis);
pre- and postlaser treatment for diabetic macular edema, because melanin in the RPE represents the single most important source of heat in thermal photocoagulation;
- monitoring of potentially retinotoxic drugs such as chloroquine and certain phenothiazine derivatives, which have an affinity for melanin.

CONCLUSION
The clinical utility of visualizing the RPE is to gauge the retina’s health and to improve early diagnostic accuracy and treatment. MSI provides en face fundus spectral slices of the retina. In addition to its utility for clinicians who specialize in retinal pathologies, the RHA has applications for the primary care clinical setting. Because visualization of melanin, lipofuscin, and hemoglobin is achievable, the primary care clinician can screen for early atypical changes in targeted populations as part of a comprehensive eye examination. With MSI technology, there is a means to monitor the RPE of patients with risk factors indicating a likelihood of developing degenerative changes (ie, family history of AMD, family history of genetic disorder, smoking) or retinal pigmentary toxicities. Likewise, the mapping of both oxygenated and deoxygenated hemoglobin provides optometrists with a noninvasive tool for differentiating a number of retinal and choroidal vascular maladies, such as endovascular leakage, macular edema, and retinal, choroidal, and optic nerve hypoperfusion. Additional features like the stereo anaglyph map allow for early screening and baseline documentation of the optic nerve. The RHA has broad application in the diagnosis of optic nerve and retinal disease, making it a potentially quintessential tool in optometric practice.

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