Ophthalmic PROFESSIONAL
Article

Modes of retinal imaging

An overview of imaging technology on the market.

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Imaging technology plays an important role in the documentation and diagnosis of retinal diseases. From traditional fundus cameras to newer techniques and devices, such as scanning laser ophthalmoscopes, ultra-widefield cameras, hybrid devices, and multimodal imaging, ophthalmologists utilize a variety of retinal images to support diagnosis and treatment decisions.

Here is an overview of currently available device types and their uses.

Traditional fundus camera

For decades, the traditional mydriatic fundus camera has been the workhorse of retinal imaging. Depending on the specific model and configuration, the fundus camera can be used for several imaging modalities, including color and monochromatic photography, fluorescein angiography (FA), indocyanine green (ICG) angiography and fundus autofluorescence. Fundus cameras typically offer a variable angle of view from 30° to 60°. To get the best images, pupils need to be pharmacologically dilated.

Mydriatic cameras are the instrument of choice for stereo photography and are required for many clinical trial protocols.

Non-mydriatic fundus camera

Non-mydriatic fundus cameras are infrared video systems that promote physiologic dilation in a darkened environment. Alignment and focus is done with infrared illumination, but image capture requires electronic flash exposure. Both pupils will constrict after a photo is taken, causing a delay between photographs. For more extensive imaging, pharmacologic dilation would be necessary for consistent high-quality results.

Non-mydriatic cameras often include features, such as autofocus, autocapture, and autoexposure. Dedicated non-mydriatic cameras are usually capable of color fundus photography only, although some offer autofluorescence imaging. They are particularly useful for imaging pediatric patients and for telemedicine screening programs.

Hybrid fundus camera

Hybrid cameras, offered by a number of manufacturers, utilize features of both mydriatic and non-mydriatic fundus cameras. These hybrid instruments can capture basic color fundus photos using the non-mydriatic mode and can be used in the mydriatic mode for angiography and fundus autofluorescence. This versatility makes them particularly useful for practices that do a high volume of color fundus photos, with the occasional fluorescein or ICG angiogram.

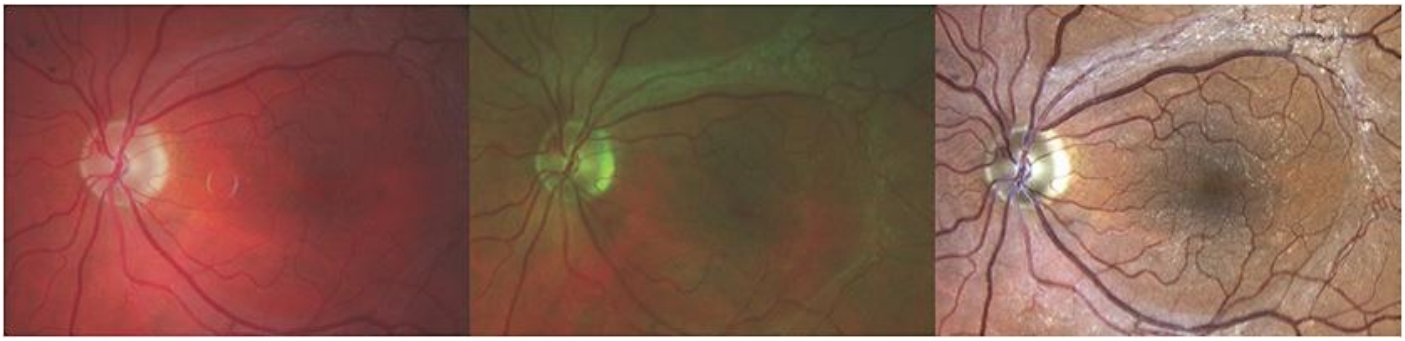

Figure 1. Color fundus comparison of the same eye using different technologies: a non-mydriatic camera (left), a scanning laser ophthalmoscope (center), and a confocal scanning laser ophthalmoscope (right). ALL IMAGES COURTESY TIMOTHY J. BENNETT

Scanning laser ophthalmoscope (SLO)

SLO employs lasers of different wavelengths that scan across the fundus in a raster pattern to illuminate and record reflectance or fluorescence, point-by-point at high speeds. This scanning technique lessens the need for pupillary dilation.

The instrument offers several retinal imaging modalities, including monochormatic reflectance, FA, ICG angiography, and fundus autofluorescence. Although not capable of true color imaging, multiple monochrome laser images taken simultaneously can be combined to create pseudo-color images.

SLOs are versatile devices in that they combine several wavelengths and modalities in a single instrument and are the underlying technology for most ultra-widefield devices (Figure 2).

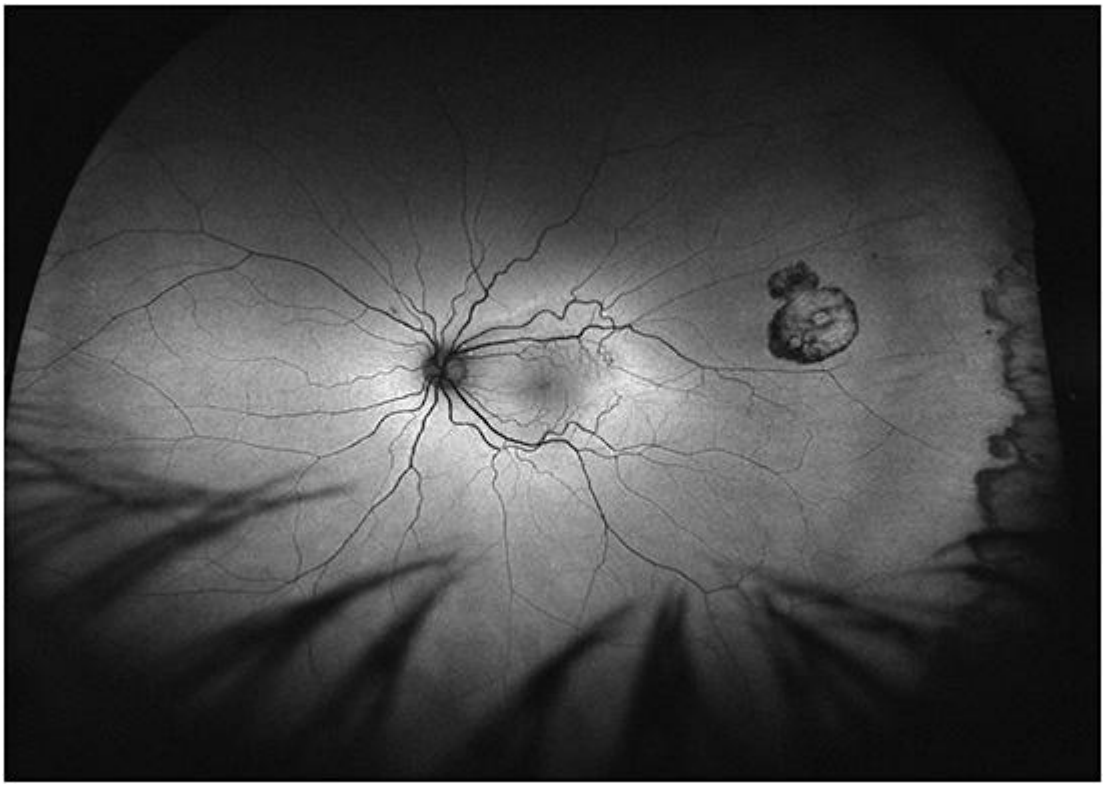

Figure 2. Ultra-widefield fundus autofluorescence image taken with a scanning laser ophthalmoscope (SLO).

Confocal scanning laser ophthalmoscope (cSLO)

Confocal imaging incorporates an aperture or pinhole that suppresses out-of-focus light from reaching the image detector, resulting in very sharp images. The pinhole is especially effective at eliminating unwanted scatter from cataracts or corneal opacities since these structures fall far outside the plane of focus. This optical design provides overall image contrast, but can also alter the appearance of some ocular structures because they are slightly out of focus. Retinal structures that scatter light or are slightly elevated will usually appear darker than normal. Although technically an “artifact,” the effect of this tonal shift can enhance visibility of some findings.

Similar to the SLO, the cSLO offers several retinal imagining modalities including infrared reflectance, blue reflectance, FA, ICG angiography and fundus autofluorescence (Figure 3). When combined with SD-OCT in a single instrument, it provides the most comprehensive platform for multimodal retinal imaging.

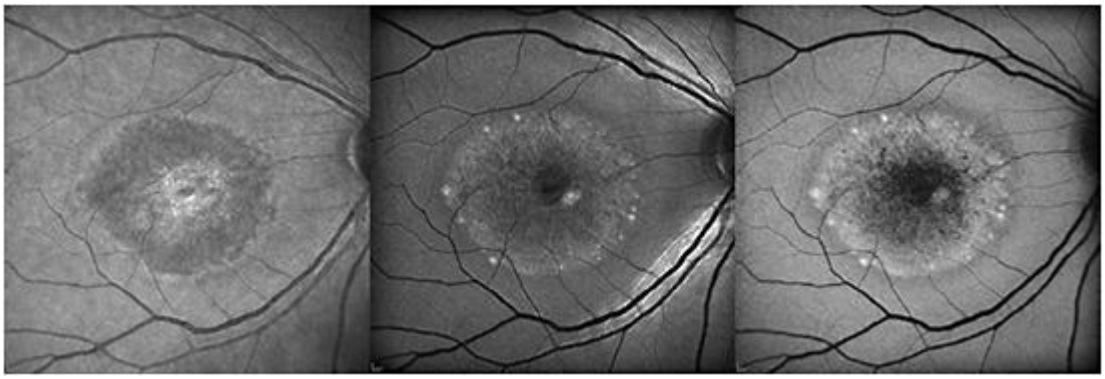

Figure 3. The confocal scanning laser ophthalmoscope (cSLO) utilizes multiple lasers at different wavelengths, including near infrared (IR), blue reflectance, and fundus autofluorescence.

Hybrid cSLO and non-mydriatic fundus camera

One manufacturer (CenterVue) has developed a hybrid device that combines confocal scanning technology in a non-mydriatic fundus camera. It is different than a cSLO in that it uses a broad spectrum white light LED rather than monochromatic lasers. It takes advantage of the small pupil capability of confocal scanning for full color fundus and autofluorescence imaging. It is capable of capturing full color images through a smaller pupil than most other devices, although the color appearance is quite different than either a fundus camera or cSLO color images.

Ultra-widefield imaging

Ultra-widefield imaging of the peripheral retina has increased in popularity over the last several years. Instruments that fall in this category have an angle of view of 100° or more. These devices are particularly helpful in documenting peripheral retinal and choroidal diseases, including diabetic retinopathy, choroidal lesions, vasculitis, uveitis, retinopathy of prematurity, as well as retinal tears or detachments.

Portable ultra-widefield designs include a small optical hand piece tethered to a control unit. A coupling gel is used between the front surface of the hand piece and the cornea. These systems are capable of color photography and FA. Also on the market is an ultra-widefield camera capable of full color and autofluorescence imaging at a 133° field of view (Carl Zeiss Meditec). Full-color imaging is achieved with red, green and blue broad-spectrum LEDs that may provide more natural color reproduction than narrow-band lasers.

When comparing ultra-widefield devices, be aware that the method of calculating the field of view and the aspect ratio of the images are often different, so the magnification specifications may not be equivalent.

On the market

» *Mydriatic fundus cameras:* Topcon Medical Systems

» *Non-mydriatic fundus cameras:* Canon USA, Carl Zeiss Meditec, CenterVue, Kowa American Corporation, Nidek, and Topcon Medical Systems

» *Hybrid mydriatic/non-mydriatic fundus cameras:* Canon USA, Carl Zeiss Meditec, Kowa American Corporation, and Topcon Medical Systems

» *Scanning Laser Ophthalmoscope:* Optos (ultra-widefield)

» *Confocal scanning laser ophthalmoscope:* Heidelberg Engineering and Nidek

» *Hybrid cSLO and non-mydriatic fundus camera:* CenterVue

» *Ultra-widefield imaging:* Natus Medical and Phoenix Technology Group, for portable devices, as well as Carl Zeiss Meditec

» *SLO/cSLO with widefield capabilities:* Heidelberg Engineering and Ocular Instruments for lenses capable of integrating with Spectralis cSLO, and Optos

Widefield technology with SLO/cSLO

One manufacturer (Heidelberg Engineering) offers a widefield lens as an auxiliary of its cSLO. It is a non-contact design with a field of view of 100°. It can be used for IR reflectance imaging as well as fluorescein and ICG angiography. Additionally, another manufacturer (Ocular Instruments) offers an auxiliary contact lens with a 150° view also for use with the cSLO. A third manufacturer (Optos) offers a series of SLO-based ultra-widefield imaging devices that provide a field of view of up to 200° in a single view.

As scanning lasers, these devices don't offer full color imaging but provide composite color capabilities by combining red and green laser images. Monochromatic imaging with red choroidal and green (red free) lasers provide additional modalities along with autofluorescence, fluorescein, and ICG angiography.

Multimodal Imaging

With a wide variety of imaging devices and technology available today, many clinicians utilize multimodal imaging techniques to provide a comprehensive look at retinal disease (Figure 4). This technique often combines reflectance imaging at multiple wavelengths along with autofluorescence, angiography, and OCT with each modality providing another piece of the diagnostic puzzle. Many manufacturers combine several of the technologies discussed here to offer multiple imaging modalities in a single device (for example, OCT combined with SLO imaging or non-mydriatic fundus cameras in one platform). Expect this trend to continue as new technologies emerge. **OP**

Figure 4. Multimodal imaging combines several imaging technologies, often from multiple devices, to provide comprehensive diagnostic information.

Mr. Bennett is an ophthalmic photographer in the Penn State Eye Center. He is a nationally recognized author, lecturer, and educator in the field of ophthalmic photography. He has served as president of the Ophthalmic Photographers' Society and a commissioner to JCAHPO. He has no financial interewst in the devices discussed.

Ophthalmic Professional, Volume: 7, Issue: July/August 2018, page(s): 16, 18, 21
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