

The Clinical Utility of Ultra-Wide-Field Imaging

A look at four widely available methods of imaging the peripheral retina that are making photography more clinically practical.

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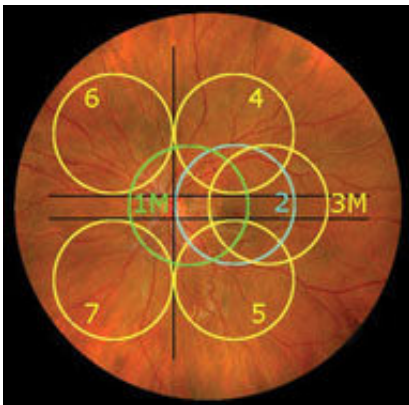


Figure 1. Diagram illustrating the extent of field of view of the ocular fundus with seven standard fields, using a conventional fundus camera.

The peripheral retina is the site of pathology in many ocular diseases. These conditions include diabetic retinopathy; retinal vein occlusions; choroidal masses; vasculitis; uveitis; choroidal dystrophies; retinal tears and detachments; Coats' disease; familial exudative vitreoretinopathy (FEVR); and incontinentia pigmenti, among others. Currently, the gold standard for a complete evaluation of the retinal periphery includes a dilated retinal examination with indirect ophthalmoscopy and often requires scleral depression. However, advancements in ocular imaging technology are making evaluation and documentation of the retinal periphery through the use of photography more practical in a clinical environment.

Evolution

Since the invention of the ophthalmoscope in 1851 by Hermann von Helmholtz, visualization of the posterior segment of the eye by ophthalmologists has undergone dramatic improvements. Obtaining photographs of the posterior segment of the eye has always been challenging because illumination of the posterior segment is required simultaneously with visualization of the ocular structures by the photographer. The first reliable fundus camera was introduced by Carl Zeiss and J.W. Nordensen in 1926, and this allowed for documentation of ocular fundus structures. This camera provided a 20-degree field of view, but it wasn't until years later that the Carl Zeiss Co. set a 30-degree field of view as the standard in ocular fundus photography.¹ This field of view was adequate for imaging of the optic nerve and the posterior pole, but provided a limited view of the retinal periphery. Throughout the years, several advances have been made to posterior segment imaging. These currently provide the clinician with several options for posterior segment documentation and evaluation.



Figure 2. Color wide-field Optos image of the right fundus of a normal patient.

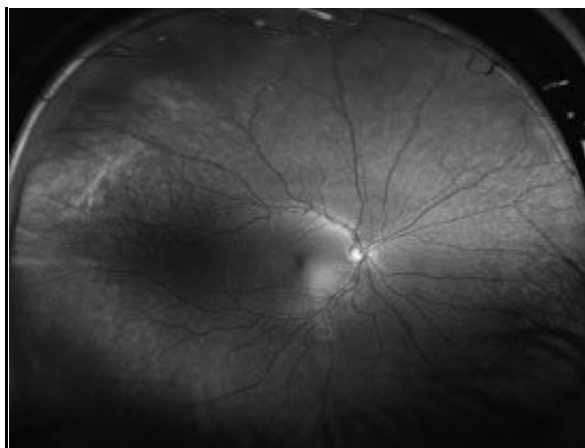


Figure 4. Wide-field image of the fundus of the right eye of a patient using the green laser of the Optos. The retinal blood vessels and the anterior retinal structures are accentuated.

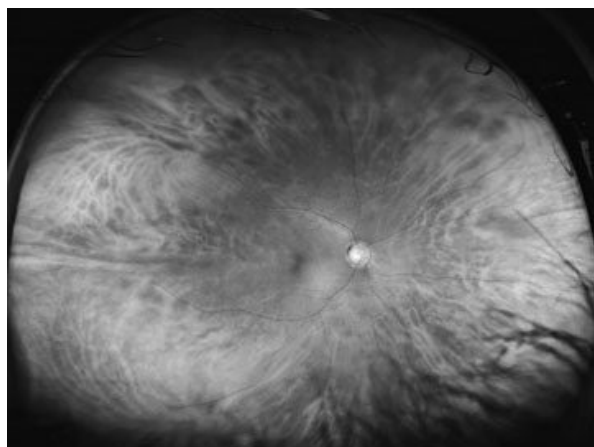


Figure 3. Wide-field image of the fundus of the right eye of a patient using the red laser of the Optos. The choroidal blood vessels are accentuated.

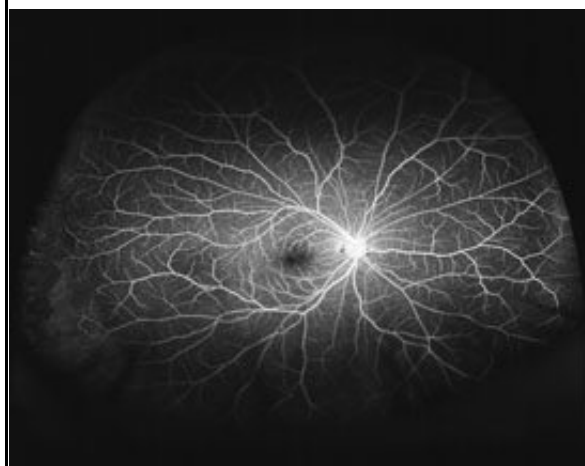


Figure 5. Wide-field fluorescein angiogram of the normal fundus of the right eye of a patient using the Optos.

There are currently four primary modalities that permit imaging of the retinal periphery in a practical manner and that are widely available. These include the use of a traditional fundus camera, with peripheral sweeps to areas of interest in the periphery; the Ocular Staurenghi 230 SLO Retina Lens (Ocular Instruments, Bellevue, Wash.) with the use of a scanning laser ophthalmoscope camera; the Retcam (Clarity Medical Systems, Pleasanton, Calif.); and the Optos (Optos, Dunfermline, UK).

Traditional fundus cameras may provide images of the retinal periphery if the objective lens is directed towards the periphery. The Diabetic Retinopathy Study detailed a method of acquiring images of the retinal periphery in a systematic manner.² This strategy utilizes traditional lenses to take multiple photographs of the posterior pole, which can then be viewed independently or fused into a montage (See Figure 1). Seven standard fields, when viewed collectively, create an image that covers about 75 degrees field of view. Although the seven standard fields image the mid-peripheral retina very well, they will not image structures in the far periphery. This has been demonstrated specifically in regards to peripheral pathology, such as is present from diabetic retinopathy and sickle cell retinopathy.^{3,4}

The Retcam is a portable wide-angle camera system that offers convenient imaging of the posterior pole. It was made commercially available in 1997. The system consists of a contact lens and offers several different lens attachments, depending on the operator's goals. The widest field lens provides for 130 degrees field of view. The system is particularly well-suited for imaging pediatric patients because it is portable and can be placed directly on a patient who is supine. This system, however, has difficulty imaging through lens opacities, which are rare in infants. Specifically, this imaging modality has been well-studied in patients with retinopathy of prematurity.⁵⁻⁹

Recently, imaging of the ocular fundus has been possible through the use of scanning laser ophthalmoscopy (SLO). This technology uses laser light and the principles of confocal laser scanning microscopy to yield images with high resolution. The Heidelberg HRA (Heidelberg Engineering) can be used to create wide-field images if used in conjunction with a wide-angle lens, such as the Staurenghi lens system.¹⁰ The Staurenghi lens system is a contact

lens that is applied prior to imaging and produces a wide-field inverted image of the ocular fundus.

The Optos camera also employs scanning laser ophthalmoscopy technology and is capable of producing wide-field images (See Figure 2). Introduced in 2000, the Optos is the first camera capable of producing 200 internal degrees field of view, which equates to about 82.5 percent of the total retinal surface area.¹¹ The technology utilizes an ellipsoid mirror to obtain images of the retinal periphery without the need for bright illumination lighting or a contact lens, and in some patients, pupillary dilation. The current model uses a red (633 nm) (See Figure 3) and green laser (523 nm) (See Figure 4) to scan the retina and obtain the images. The images created by each of these laser wavelengths may be separated into their individual components.

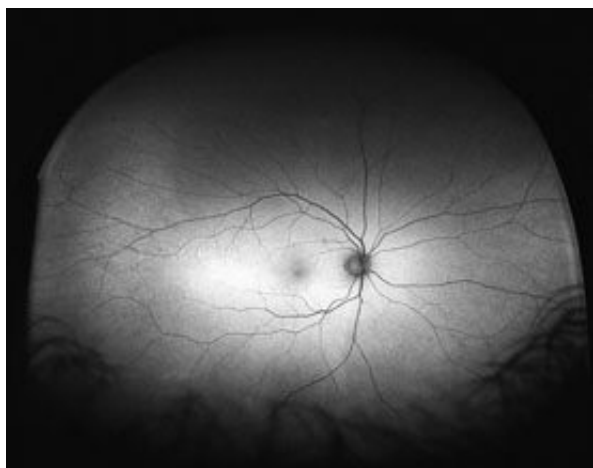


Figure 6. Wide field fundus autofluorescence image of the right eye of a normal patient with the Optos.

In addition to obtaining fundus photographs of the retinal periphery, the Optos has several other capabilities for ocular imaging. Since the initial report on fluorescein angiography in 1961,¹² ophthalmologists have utilized this imaging technique to evaluate the blood vessels and circulation within the eye. The Optos is capable of producing high-resolution fluorescein angiogram images of the retinal periphery (See Figure 5). These are particularly clinically useful in eyes with retinal vascular disease. In addition, the Optos is also capable of producing autofluorescence images, which are valuable in disorders that affect the retinal pigment epithelium (See Figure 6).

Research into several retinal diseases that affect the anterior retina has been performed using wide-field imaging. The use of wide-field angiography to image the anterior retina of patients with diabetic retinopathy, for example, has been shown to enhance the clinical evaluation (See Figure 7).³ In addition to identifying areas of capillary non-perfusion and neovascularization, the wide-field images of diabetic patients can be instrumental in planning surgical or laser treatment.¹³ In addition to diabetic retinopathy, retinal vasculitis and uveitis often present with peripheral vascular changes. Fluorescein angiography is able to detect vessel inflammation and incompetence that may be difficult to detect on peripheral retinal examination with an indirect ophthalmoscope. Wide-field fluorescein angiography enhances this evaluation. For example, in the case of sickle cell retinopathy, a recent report demonstrated that wide-field imaging was able to image the peripheral retinal vascular pathology—not possible with traditional seven standard fields.⁴ Further research into the utility of wide-field imaging in pathologies such as retinal detachment, choroidal dystrophies and even macular degeneration is ongoing.

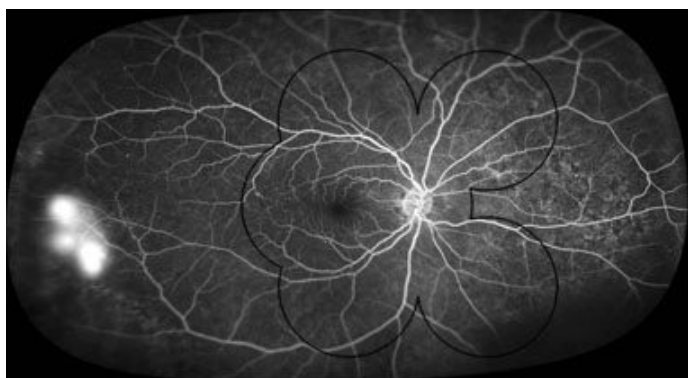


Figure 7. Wide-field fluorescein angiogram of the right eye of a patient with diabetes using the Optos, demonstrating peripheral neovascularization temporally and illustrating how the area covered by the seven standard fields would not image this finding.

Limitations

Although these imaging modalities are changing the way that clinicians practice medicine and have become valuable research tools, wide-field imaging currently has several limitations. It is important for a clinician to be aware of these drawbacks in order to appropriately analyze the volume of information that wide-field images provide. The first limitation that is critical to recognize is the inability of wide-field imaging to image the ora serrata 360 degrees with a single image. Specifically, imaging of the anterior retina superiorly and inferiorly is limited with this modality. The current available modalities of retinal imaging, therefore, do not replace the use of indirect ophthalmoscopy with scleral depression to evaluate the anterior retina in all quadrants. Another limitation is the fact that the imaging technique requires training of the photographer in a new modality. For example, unlike in traditional fundus photography, the photographer using the Optos is not provided with an image of the retinal area that will be photographed prior to the capture of the image. Lastly, when using the Optos, the ellipsoid mirror and the spherical nature of the globe result in distortion of the peripheral image and prevent direct measurement of the peripheral retinal structures on the image.

Imaging of the peripheral retina has significantly improved over the past several decades. Wide-field technology has become important clinically with regards to diagnosis, treatment, and monitoring of several diseases. In addition, wide-field imaging has demonstrated significant utility in a research capacity. It is likely that with additional time, the full utility of wide-field imaging will be revealed. **REVIEW**

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