Editorial

Future in retinal imaging for clinicians

Starting from the fundus photography, followed by fundus fluorescein angiography (FFA), and so on, retinal imaging has been an essential component of retina clinics. Further advancement into high-resolution imaging of tissues and *in vivo* histopathological images of the retina using the optical coherence tomography (OCT) has improved our understanding of the pathologic process in various ocular and systemic diseases. Improving the resolution, making it noninvasive and seeing beyond what our eyes can see, has been the motivation for innovations in retinal imaging. Newer developments have made provision for the assessment of the metabolic status of the retina, wider view of the periphery and functional status of the different retinal layers. In this special issue on retinal imaging, we have put together articles that discuss newer imaging modalities and their clinical applications.

Some imaging concepts are still in the research and development stage. While few are being used commercially, there are others, which will soon be made available for use in clinical practice to allow for optimal patient management.

Multicolor Imaging

Different wavelengths of light have been used to image different layers of the retina and as well as the choroid. Each laser with a different wavelength penetrates to a different depth within the retina, capturing specific information from each layer of the retina.[1] The shorter wavelength, blue laser provides details of superficial retinal structures such as epiretinal membranes, retinal folds, the retinal nerve fiber layer and macular pigments. The medium wavelength, green is highly absorbed by hemoglobin and provides details of vascular abnormalities of blood vessels such as microaneurysms and exudates. The longer wavelength, infrared laser penetrates the deepest layer, providing images of the retinal pigment epithelium (RPE) and the choroid and is particularly useful for imaging deeper lesions such as choroidal rupture, drusen, and choroidal nevi. However, obtaining three kinds of images in a single subject could be a very difficult task especially for the elderly or uncooperative subjects. Newer version of the Spectralis® (Heidelberg Engineering, Heidelberg, Germany) offers multicolor imaging which uses multiple laser wavelengths including blue, green and infrared simultaneously to selectively capture and provide information of different retinal structures from a single image during a single examination. With the help of confocal technology and eye tracking, the image quality is very good. Simultaneous OCT can be captured passing through the area of interest. Multicolor imaging helps in easier and earlier detection of various pathologies such as age-related macular degeneration (AMD) and diabetic retinopathy when compared to a conventional color photograph.

Wide Field Imaging

Imaging of the periphery is becoming an essential component of the management for various retinal diseases especially in pediatric patients. Using the conventional fundus camera, the retinal periphery could only be imaged when assisted by patient eye movement in that specific direction and good pupillary dilatation. Various modalities have been tried such as the Retcam (Clarity MSI, Pleasanton, CA, USA), Panoret (Medibell Medical Vision Technologies Ltd., Haifa, Israel), and Staurenghi lens (Ocular Instruments, WA, USA) in the past.[2,3]

One of the more recent systems includes the Optos camera (Optos PLC, Dunfermline, UK), a confocal scanning laser ophthalmoloscope that can image the peripheral retina up to 200°, and up to the ora serrata in a cooperative patient in a single flash without the need for a contact lens or pupillary dilatation. It uses an ellipsoid mirror to obtain images of the retinal periphery. It uses two wavelengths, green (532 nm) to image the retinal structures and red (633 nm) to image the choroidal vasculature. In addition, wide field angiography is useful in the diagnosis of peripheral avascular retina and targeted laser photocoagulation in diabetic retinopathy and venous occlusions; imaging of peripheral tumors; early diagnosis of peripheral neovascularization in uveitis; management of vasculitis; and pediatric retinal diseases.[4] Wide field autofluorescence has been reported to be useful in pigmented choroidal lesions to differentiate between benign and malignant lesions.[5] Limitations of the Optos® camera includes the inability to image the whole retina, poor resolution of the posterior pole, distortion, inability to view the retina before image acquisition and artifacts. Despite several innovations in wide field imaging, binocular indirect ophthalmoscopy examination with scleral depression still remains the gold standard.

Wide Field Optical Coherence Tomography

Advances in OCT technology has improved the resolution from 10 microns to 3–4 microns. However, the scan length remains 6–9 mm. Montage of spectral domain (SD)-OCT scans have been tried to obtain information of peripheral retinal diseases without much success. Recently, wide field OCT is possible with the Avanti RTVue-XR® (Optovue, Inc., CA, USA), which can create 12 mm × 9 mm B-scans with a resolution of 3 μm. This would gradually improve the evaluation of the lesions from the arcade to the macula as well as improve the understanding of peripheral retinal diseases such as choroidal tumors or retinoschisis. This would also be helpful in evaluating multifocal macular diseases and vitreous connections at the optic nerve head.

Phase-variance Optical Coherence Tomography

Phase-variance-OCT (PV-OCT) angiographic imaging is based on the contrast of moving versus static tissues. Therefore, it is particularly well suited to display the fine structure of the capillary networks. Three-dimensional imaging with PV-OCT generates high-resolution imaging of retinal and choroidal vasculature using the SD-OCT.[6] Due to increased SD-OCT imaging speeds and less motion artifacts with PV-OCT, it is possible to visualize slow microvascular flow independent of vessel orientation in contrast to Doppler OCT. PV-OCT angiography can be obtained noninvasively without any hardware alterations in available SD-OCT instruments.

Phase-variance-OCT provides information of different levels of vessels separately for the retina as well as for the choroid. It provides comparable information in healthy as well as diseased eyes as compared to the conventional FFA.[6,7] It is helpful in early detection of choroidal neovascularization in AMD subjects and microaneurysms and neovascularization elsewhere (NVE) in diabetic retinopathy, even in the presence of hemorrhage.[6] Its utility has been demonstrated in the evaluation of choriocapillaris in geographic atrophy and its progression.[7] In addition, PV-OCT can visualize vasculature independent of regional leakage due to contrast differences. With this capability, vascular response to the antiangiogenic therapeutics can be directly visualized, even in the presence of leakage, which is not possible with the other angiography methods. The noninvasive nature of this imaging method permits more frequent use than conventional angiographic techniques currently in use.

Limitations of PV-OCT include shadow artifact, small field, lack of information about leakage or staining, lack of fixation tracking, and loss of OCT intensity signal within large choroidal vessels.

Adaptive Optics Scanning Light Ophthalmoscope Fluorescein Angiography

Adaptive optics provides *in vivo* microscopic images of the retina including the photoreceptor mosaic, RPE, nerve fiber layer and microvasculature.[8] Richard Rosen's group from New York reported the use of adaptive optics scanning light ophthalmoscope along with fluorescein angiography (AOSLO FA) to provide visualization of the retinal microvasculature. AOSLO FA, with oral or intravenous fluorescein, can visualize the retinal capillary beds at all retinal locations and at multiple depths with qualitatively comparable contrast and sharpness.[9] Using this technology, they have classified microaneurysms in diabetic retinopathy into six different types and reported other qualitative parameters such as intraluminal hypofluorescent region and identification of nonperfused capillaries.[10] Clinical application of this information may be useful in better understanding microvascular disease progression and deciding a more successful therapeutic approach.

Oximetry

Oximetry is a technique of measuring oxygen saturation in the retinal blood vessels, which also gives us an estimate of the quality of blood flow.[11] Since the retina offers the advantage of direct visualization of blood vessels, oximetry can allow early differentiation of disease from normal. It has the potential for early diagnosis and follow-up of various conditions besides giving an indication of possible systemic disease.

Determining the oxygen saturation can be beneficial in conditions like retinal vascular occlusions and diabetic retinopathy. It can also contribute to the knowledge of ocular blood flow and its role in the pathogenesis of glaucoma. A good correlation between retinal arterial and peripheral arterial oxygen saturation was also noted in one study.[12] Future prospects for oximetry include integration with a scanning laser ophthalmoscope and its applicability in predicting systemic disease from retinal oxygen saturation values.[13]

There are various technologies, which are still at the conceptual level and engineering that have to come into clinical practice. Still the challenges to be dealt are: improving the speed of acquisition, reducing the artifacts, improving the light safety, development of user-friendly software, and the last but not the least, reducing the cost of the instruments. Certainly, these advanced imaging technologies would provide in-depth information about the pathological process and may help to describe newer findings in retinal diseases.

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