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ADVANCES IN OPHTHALMOLOGY AND OPTOMETRY

Advances in Retinal Imaging

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• Optical coherence tomography angiography
• Intraoperative optical coherence tomography

Key points

- Over the last few decades, retinal imaging has become an essential component of clinical evaluation, and the field of retinal imaging continues to enjoy rapid advancement.
- Multiple novel retinal imaging modalities are emerging, including adaptive optics, quantitative fundus autofluorescence, wide-field imaging, swept source optical coherence tomography (OCT), en face OCT, OCT angiography, intraoperative OCT, and portable retinal imaging.
- These modalities are leading the way for improved understanding of retinal pathophysiology as well as enhanced documentation, screening, diagnosis, monitoring, and treatment.

INTRODUCTION

Among the medical specialties, ophthalmology is perhaps the most technologically driven. Medical lasers have become widely used, from refractive and cataract surgery to treatment of retinal diseases. Similarly, over the last few decades, retinal imaging has revolutionized the understanding of

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retinal disorders and has become an essential component of clinical evaluation.

In the 1950s, the advent of electronic flashes and the 35-mm camera gave birth to the field of modern fundus photography, which enhanced clinical documentation and the study of retinal diseases. The 1960s and 1970s gave rise to fluorescein angiography (FA) and indocyanine green angiography (ICGA), which revolutionized the ability to evaluate the integrity of the chorioretinal vasculature. Scanning laser ophthalmoscopy (SLO), first introduced in the 1980s, marked a change in photographic capture technique. A single spot of laser light at a specified wavelength is scanned across the retina in a series of parallel lines, allowing usage of much lower light levels with better images due to reduced light scatter [1]. A large area of the fundus is scanned, and individual images are collated with software. Furthermore, development of confocal scanning, which uses a spatial pinhole to block out-of-focus light, further reduced light scatter and increased optical resolution and contrast, allowing micrometer precision axial resolution. This technique was combined with the lateral resolution offered by SLO. Furthermore, these images can be acquired through a nonmydriatic pupil. The 1990s saw the introduction of optical coherence tomography (OCT), a wholly new form of noninvasive imaging. It added a new dimension to retinal imaging with the ability to develop cross-sectional images of retinal tissue to a submicron axial resolution using a low-coherence interference technique combined with a broadband light source [2]. TD-OCT initially and later spectral domain OCT (SD OCT) techniques have further improved axial resolution of tissue cross-section. Advances in retinal imaging have revolutionized modern ophthalmic practice. These technologies have allowed accurate and reproducible documentation of retinal abnormalities, improved the understanding of retinal pathophysiology, and enhanced diagnosis, staging, monitoring, and treatment of retinal diseases [3].

The field of retinal imaging continues to enjoy rapid advancement. Multiple novel retinal imaging modalities are emerging, including adaptive optics (AO), quantitative fundus autofluorescence (qAF), wide-field imaging, swept source OCT, en face OCT, OCT angiography (OCTA), intraoperative OCT, and portable retinal imaging. This article provides an overview of these exciting imaging modalities, which are likely to enhance the provision of eye care in the coming decades.

ADAPTIVE OPTICS

AO is a relatively novel imaging modality with the capacity for cellular level resolution. It first was used in astronomical telescopes to correct atmospheric aberrations that limited resolution. In the eye, AO compensates for aberrations caused by irregularities in the optics of the eye to achieve excellent resolution (≈ 2 μm) [4]. An AO system consists of a wavefront sensor to measure optical irregularities, a system of small mirrors that adjust to compensate for the measured irregularities, and software to control these interactions.

AO enables direct visualization of rod and cone photoreceptors (Fig. 1), retinal pigment epithelial (RPE) cells, lamina cribrosa, and retinal blood vessels.

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