OCT Technology - What is coming.

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History of OCT

Optical coherence tomography (OCT) was first reported by Huang et al. in 1991. It is a high-resolution, non-invasive, *in vivo* ophthalmic imaging technique that gives excellent cross-sectional images of the retina. Similar to ultrasound, OCT uses low coherence interferometry to detect echo time delays of light. The first devices were based on time domain (TD) detection technology in which the reference arm moves mechanically and light echoes from time delays are measured sequentially. The first commercially available TD OCT devices featured speeds of 400 A-scans/second.

Newer OCT devices are based on spectral domain (SD) detection, a type of Fourier domain detection, OCT uses a stationary reference arm, a high-speed spectrometer, and CCD camera to detect light echoes simultaneously thus increasing acquisition speed by 20-100 times. More than a half dozen SD-OCT machines are commercially available. Acquisition speeds for these devices are between 25,000- 52,000 A-scans/second with axial resolution from ~3 to 7 µm.

Hardware Innovations

1. Faster Speed

Advantages of Faster Speed
The increase in imaging speed offered by high-speed or spectral OCT provides four main advantages.

1. Pixel averaging means dramatic reduction in speckle noise, allowing for higher image quality
2. Reduction of motion artifacts
3. Increased area of retinal coverage
4. 3 D data sets to create topographic maps with precise registration

What's next for faster speed?

Swept-source laser (SS-OCT)
SS-OCT uses a narrowband light source, typically a tunable, narrow-line width laser, that is rapidly tuned over a broad optical bandwidth. A-scan information is obtained by measuring the Fourier transform of the interference spectrum over time. Photodetectors, as apposed to spectrometer and line camera, are employed, greatly increasing imaging speeds to 300,000 axial scans per second with balanced detection. SS-OCT confers better sensitivity and improved depth range of imaging.

2. Increased Resolution

Broader bandwidth light sources improve OCT B-scan images. Software modifications which allow for frame averaging and eye tracking to follow even the slightest eye movements allows a large number of B-scans to be acquired in the same precise location. By averaging scans together, speckle noise can be reduced to improve image quality.

3. Longer Wavelength Light Sources

Most commercially available SD OCT units employ broad-bandwidth superluminescent diode (SLD) with bandwidths centered at a wavelength of 830 nm. It is possible to perform OCT imaging past the maximum water absorption peak around 1050 nm wavelength. Longer wavelengths mean less light scatter and deeper penetration. OCT imaging at 1050 nm delivers deeper tissue penetration to image structures beneath the RPE, such as the choroid.

4. Functional OCT

Polarization sensitive OCT (PS-OCT)

PS-OCT (depth-resolved tissue birefringence) provides tissue specific contrast between the birefringent RNFL layer and other retinal layers. This permits direct identification of retinal layers based on the intrinsic properties of their interaction with light. This technique may provide information about the architectural and cellular organization of retinal nerve fibers and may allow for detection of changes in structure before there is a change in RNFL thickness.

5. Intraoperative OCT

Intraoperative OCT is being studied as an adjunct to vitreoretinal surgery. There are both microscope based prototypes and commercially available hand-held systems that can be used intraoperatively.

Software Innovations

1. Doppler OCT

Doppler OCT systems allow measurement of retinal blood flow velocity through retinal vessels by the assessment of light reflectivity changes in retinal blood vessels over very short time periods.

2. C mode (*En-face*) imaging

En face (C mode) imaging is a software technique which employs dense 3D OCT data sets which are re-assembled into a fundus view. This view enables assessment of microstructure and anatomic relationships which would not otherwise be apparent.

Conclusions

In the future, OCT technology holds the promise for both continuing research advances and improvements in clinical care. Improvements in OCT technology will increase the sensitivity and specificity of early disease detection and enable improved monitoring of disease progression and therapy, as well as allowing better understanding of retinal biology and function on a micron level.