Optical Coherence Tomography Assessment of Macular Oedema

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Core Messages

- Optical coherence tomography (OCT) is a novel non-contact examination technique of the macula
- The high resolution of 10 µm is achieved by using the physical mechanism of coherence interferometry
- OCT allows new diagnostic criteria to be defined for macular oedema without subjecting the patient to fluorescein angiography
- Therapeutic decisions can be taken on the basis of OCT images, and macular oedema may be monitored very easily after medical or surgical treatment
- OCT is particularly useful in the assessment of diabetic macular oedema and of macular oedema associated both with age-related macular degeneration and with vitreomacular traction syndromes
- In the future, ultrahigh-resolution OCT, which uses a titanium-sapphire laser light source, may give an image resolution of up to 3 µm
- Ultrahigh-resolution OCT will be especially useful in the exact localization of subfoveal or sub-RPE choroidal neovascular membranes with important consequences for their medical or surgical management

1.1 Introduction

Optical coherence tomography (OCT) is a new medical diagnostic technology, which can perform micron resolution tomographic cross-sectional imaging of biological tissues [8, 17, 28, 33]. The initial development of the technology was pioneered at the Massachusetts Institute of Technology in Boston, USA, and the first OCT machines became available for widespread clinical use around 10 years ago. After the first two generations of scanners, the latest type has been available on the global market since 2002. Apart from its use in ophthalmology, OCT technology has also been applied in many other medical subspecialties such as urology, dermatology and cardiology, but also in non-medical fields such as engineering.

1.2 Principles of Operation and Instrumentation

1.2.1 Optical Tomography Versus Ultrasound

Cross-sectional imaging of the posterior pole has for many years been only possible with ultrasound, whose resolution depends directly on the frequency or wavelength

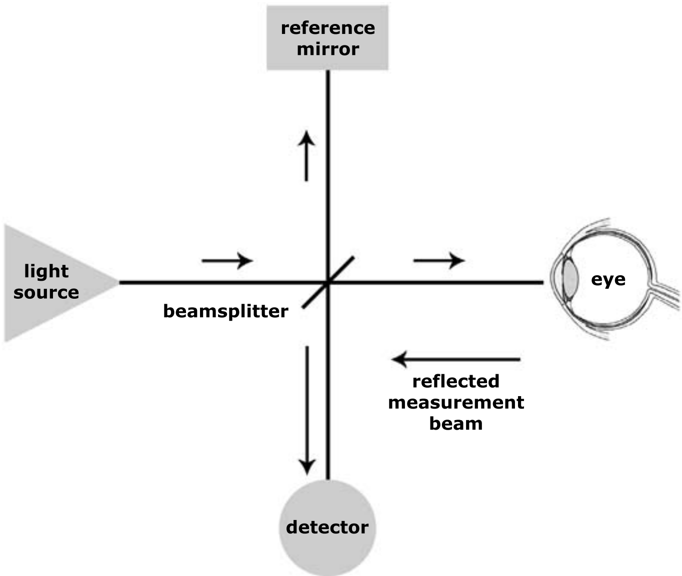

Fig. 1.1. Schematic diagram depicting the optical pathways of the OCT machine. The central beam splitter sends one part to the reference mirror, and the other part to the imaged tissue. If the two light pulses coincide when they are reflected back to the detector, they produce a phenomenon known as interference. This is measured by a light-sensitive detector, which then transforms the signal into the OCT image on the screen

of the sound waves. It yields a spatial resolution of approximately 150 µm at the posterior pole. Recently, high-resolution ultrasound imaging systems have been developed, which use higher frequency sound waves and which have resolutions on the 20-µm scale. However, due to strong attenuation in biological tissues this type of imaging can only be performed in depths of 4–5 mm, limiting the application to the anterior segment of the eye.

Imaging with OCT is analogous to ultrasound B-mode imaging, except that *light* is used rather than acoustic or radio waves. The primary difference between ultrasonic and optical imaging is speed. The velocity of propagation of light is nearly a million times faster than the speed of sound, which allows measurements with a resolution of 10 µm at the posterior pole. In contrast to ultrasound, there is no need for physical contact with the eye during examination, which reduces patient discomfort.

1.2.2 Low Coherence Interferometry

The OCT scanner uses low-coherence interferometry to create an image (Fig. 1.1). An optical beam from a superluminescent diode laser emitting at 830 nm is directed onto an optical beam-splitter, which functions as the interferometer [17]: Half the beam is reflected from a reference mirror and the other is transmitted to the imaged tissue. The operation of the system can be understood qualitatively if one thinks of the light beam as being composed of short pulses of light. The pulse of light reflected from the reference mirror will only coincide with the pulse of light reflected from a given structure in the patient's eye if both pulses arrive at the same time. This will occur only if the distance that the light travels to and from the reference mirror precisely matches the distance that the light travels when it is reflected from a given structure in the patient's eye. When the two light pulses coincide, they produce a phenomenon known as interference, which