APPLICATIONS OF OPTICAL COHERENCE TOMOGRAPHY IN THE ANTERIOR SEGMENT OF THE EYE

Essay

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By

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CONTENTS

LIST OF ABBREVIATIONS

AC	Anterior chamber
AC OCT	Anterior chamber Optical Coherence Tomography
ACD	Anterior chamber depth
ACG	Angle closure glaucoma
ALPI	Argon Laser Peripheral Iridoplasty
AS OCT	Anterior segment Optical Coherence Tomography
CAS OCT	Corneal anterior segment Optical Coherence Tomography
CBS	Capsular block syndrome
CCI	Clear corneal incision
CCT	Central corneal thickness
CD	Corneal diameter
CHC	Corneal hydration control
CLR	Crystalline lens rise
INTACS	Intra-stromal corneal segments
IOL	Intraocular lens
IOP	Intraocular pressure
LASIK	Laser insitu keratomileusis
LTK	Laser thermokeratoplasty
LPI	Laser peripheral Iridotomy
mm	millimeter
mW	milliwatt
nm	nanometer
OCT	Optical Coherence Tomography
PCO	Posterior capsular opacification
PDS	Pigment dispersion syndrome
PIOL	Phakic Intraocular lens
PRK	Photorefractive Keratectomy
PTK	Phototherapeutic Keratectomy
SEB	Scleral expansion band
US	Ultrasound
UBM	Ultrasound Biomicroscopy
WTW	White to white

LIST OF FIGURES

Proper evaluation of the anterior segment of the eye is vital. In addition to conventional methods of ocular examination, investigative imaging techniques are very important.

Anterior segment imaging has made tremendous strides since the introduction of the slit lamp biomicroscopy. When the slit illumination device of Gullstrand was combined with Czapski's binocular microscope in 1916, a major advance was marked as more accurate 3-dimentional visualization and localization of anterior segment pathology became possible. Subsequent advances in anterior imaging included slit lamp photography, anterior segment fluorescein angiography, specular microscopy, corneal topography, ultrasonic biomicroscopy, confocal microscopy, Scheimflug imaging and anterior segment Optical Coherence Tomography (OCT) ***(Dupps et al., 2006).***

OCT is an investigative imaging technology having its applications in biology and medicine. Its attractive features include high cellular-level resolution, real-time acquisition rates (high number of clear images can be taken per second) and spectroscopic feature extraction in a compact non invasive instrument. OCT can perform optical biopsies of tissues, producing images approaching the resolution of histology without having to resect for diagnosis ***(Boppart et al., 2003).***

Ophthalmologic applications of OCT began with retinal imaging before using it in anterior segment. OCT imaging of retina was helpful in identification of local defects in the nerve fiber layer that occur in early stages of glaucoma. Also, it is used as a sensitive diagnostic test for the early detection of macular thickening in patients with diabetic macular edema and for visualization and evaluation of macular holes, genetic retinal diseases, retinal detachments, retinoschisis, choroidal tumors and optic nerve disorders ***(Hrynchak et al., 2000).***

Anterior segment OCT evolved from OCT developed for posterior segment imaging and typically uses a longer wavelength infrared laser (1310 nm versus 830 nm). Because the longer wavelength is mostly absorbed by the anterior segment structures, higher power can be used without damaging the retina (15 mW for anterior segment OCT versus 0.7 mW for posterior segment OCT). Higher power combined with higher sampling rate (number of signals recorded/ second) result in higher image resolution compared to posterior segment OCT ***(Huang et al., 2004).***

High resolution imaging of OCT can overcome many of the limitations of the current techniques used to image the anterior segment of the eye ***(Radhakrishnan et al., 2001).***

Recent studies described the use of trans-scleral OCT with wavelength of 1310 nm light which allowed deeper penetration in highly scattering tissue such as the sclera. The obtained images showed morphological details better than those obtained with conventional 830 nm OCT systems ***(Radhakrishnan et al., 2001).***

Anterior segment (AS) OCT is helpful in evaluation and exploration of the anterior segment structures including tear film, cornea, iris, crystalline lens, anterior chamber, sclera and ciliary body. The 1310-nm light wavelength is blocked by pigments preventing exploration behind the iris. However, the AS-OCT is capable of providing good-quality images and a better visualization of the anatomical relationships of the anterior segment, even behind an opaque cornea ***(Biakoff et al., 2005).***

Anterior segment OCT allowed better evaluation of refractive surgeries and IOL implantation. Also, internal structures of the filtering bleb and deep sclerectomies can be visualized. This could be a new way to assess the postoperative healing process with the possibility of earlier intervention in cases of impending scarring ***(Muller et al., 2007).***

The aim of this essay is to review the role of the optical coherence tomography as a new imaging modality in evaluation of anterior segment of the eye.

Optical principle of OCT (Echo time Delay):

OCT is analogous to ultrasound except that near-infrared light waves instead of acoustic waves are used to measure distances of specific structures (Fig.1). OCT depends on optical ranging; in other words, distances are measured by shining a beam of light onto the object, then recording the echo time delay of light. Since the velocity of light is so high, it is not possible to directly measure the echo time delay of reflections; therefore, a technique known as low-coherence interferometry compares reflected light from the eye to that reflected from a reference path of known length. Different internal structures produce different time delays, and cross-sectional images of the structures can be generated by scanning the incident optical beam. Actually these two dimensional scans are black and white, however, they are displayed in a color scale where ‘warm’ colors (red to white) represent areas of high optical reflectivity, and ‘cool’ colors (blue to black) represent areas of low reflectivity ***(Puliafito et al., 1996).***

It is important to note that although the homographic image represents the true dimensions of the structure being measured, the coloring of different structures represents different optical properties and not necessarily different tissue morphology. Care must be taken to avoid interpreting images analogously to conventional histopathology. OCT imaging is similar to ultrasound where different degrees of ultrasound backscattering correspond to different color or grey levels except that in OCT images, different optical reflection and scattering properties are measured ***(Swanson et al., 1993).***