New imaging technology provides sharper picture of anterior segment

Wolfgang Haigis

Michel Puech

Cheryl Guttman in Paris

NEW imaging technologies which employ enhanced forms of optical coherence tomography (OCT) represent important options for anterior segment imaging and biometry, according to researchers at the XXII Congress of the ESCRS

Wolfgang Haigis PhD University Eye Clinic Wuerzburg, Germany, reported his one-year experience using the ACMaster (Carl Zeiss Meditec), a non-contact instrument utilising partial coherence interferometry, a technique also underlying optical coherence tomography. He used the device to study eyes of normal volunteers and of patients undergoing cataract or refractive surgery.

"With the calculated group refractive indices, it is very easy to connect all of our ultrasound experience to this new measurement system," *Wolfgang Haigis MD*

He reported that because of its precision, the ACMaster had an advantage over ultrasound for measuring central thickness of contact, intrastromal, thin, and PMMA lenses. He said it could even be used to define minute intraocular distances, such as retrolenticular gaps in pseudophakic eyes.

Comparisons of corneal thickness measurements obtained using the ACMaster and conventional ultrasound (Tomey AL2000) showed very high correlations between the two methods.

An analysis of 65 repeated measurements taken in the left and right eyes of a 50-year-old normal subject showed a high degree of reproducibility with the system. The analysis showed reproducibility of 1.8 ±0.8 microns for corneal thickness, 4.8 ± 1.3 microns for anterior chamber depth, 2.4 ± 0.9 microns for the position of the posterior lens vertex, and 5.4 ± 1.3 microns for lens thickness.

He evaluated inter-observer variability by having three examiners measure the anterior chamber depth of both eyes of a single patient each day for five consecutive days. Intra-observer variability was studied by analysis of bilateral anterior chamber depth measurements made by a solo examiner in three patients five times in a single day.

In those studies, inter-observer variability for the anterior chamber depth measurements was 4.7 ± 1.8 microns while intra-observer variability was 6.1 ± 3.6 microns.

"With the calculated group refractive indices, it is very easy to connect all of our ultrasound experience to this new measurement system," Dr Haigis said.

He found the ACMaster could also be used for analysing accommodation-related changes in the position of the anterior lens surface. Dr Haigis illustrated that application by showing results from measurements taken in a phakic and a pseudophakic eye.

Dr Haigis also used the PCI technique in a longitudinal study in which serial measurements of anterior chamber depth were taken in a single eye over nine months. The data demonstrated biological rhythms in anterior chamber depth dimensions superimposed on the natural, age-related reduction. The latter was determined to be about 100 nanometres per day.

"With its excellent precision, we can use this instrument to measure increases in lens thickness over time and see presbyopia in action. With this system we are approaching physiological limits of accuracy, and so precision is no longer determined by the hardware. This new PCI instrument is an easy and convenient way to accurately measure intraocular distances, and it promises to be of great benefit in accommodation research, refractive surgery, and IOL design studies," Dr Haigis said.

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He explained that the ACMaster has the look and feel of its companion PCI-based instrument, the IOLMaster. However, in distinction to the IOLMaster, which measures along the visual axis, the ACMaster measures along the optical axis. Therefore, the ACMaster receives enough light energy to identify interfaces and make segmental measurements of the cornea, anterior chamber, and lens.

OCT3 for the front of the eye

Ocular coherence tomography was first developed as a technique for in vivo imaging of the retina, but it also has great potential for use as a non-contact technique to provide high-resolution images of the cornea and anterior segment, said French ophthalmologist Michel Puech, MD.

He and his associate, Adil Elmaftouhi, have been working with a customised version of the OCT3 (Carl Zeiss Meditec) in which they modified the exit lens to focus on the cornea and anterior segment rather than the posterior pole. His experience indicates the system can be used in a variety of indications for studying anterior segment pathology and in refractive surgery.

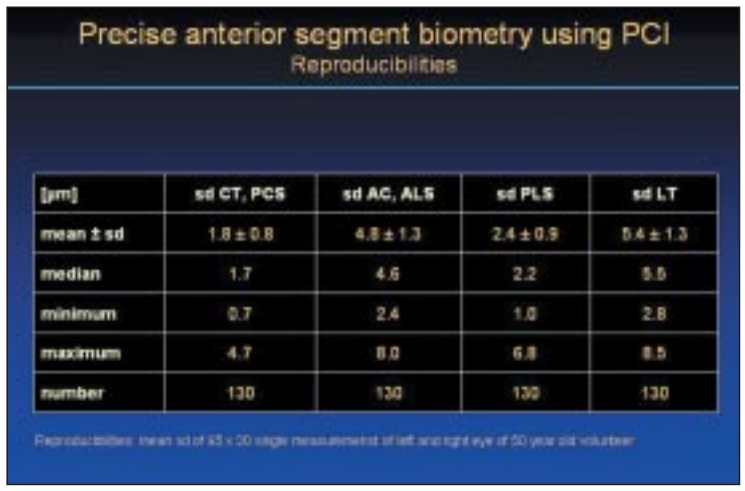
"This system would provide users the advantage of having a single instrument for observing the retina, cornea, and anterior segment." *Michel Puech MD*

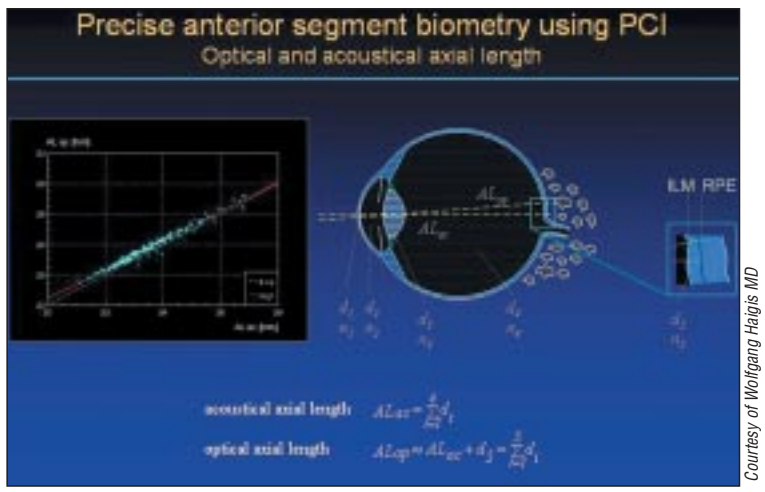
However, in its current iteration, the modified OCT3 is inferior to some other anterior segment imaging technologies for some applications because its infrared beam has limited penetration through the iris.

"This system would provide users the advantage of having a single instrument for observing the retina, cornea, and anterior segment. However, we await further developments to expand its utility for anterior segment imaging," said Dr Puech.

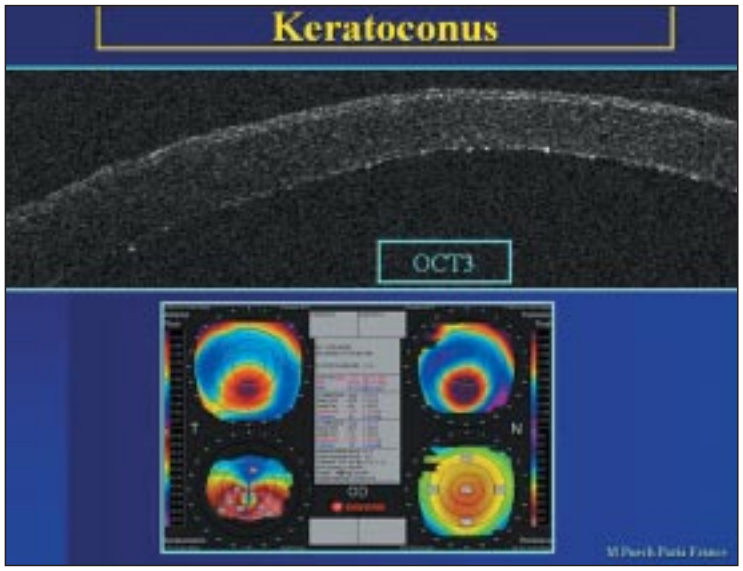
On the other hand, with its high resolution, the modified OCT device is an ideal technology for corneal imaging. Dr Puech illustrated that application showing cases where the modified OCT3 was used to characterise curvature changes in an eye with keratoconus, for measuring residual stromal thickness post-LASIK, to visualise wound healing of a radial keratotomy (RK) incision, to see a penetrating RK incision, and to show the irregularity of the stroma in an eye with diffuse lamellar keratitis.

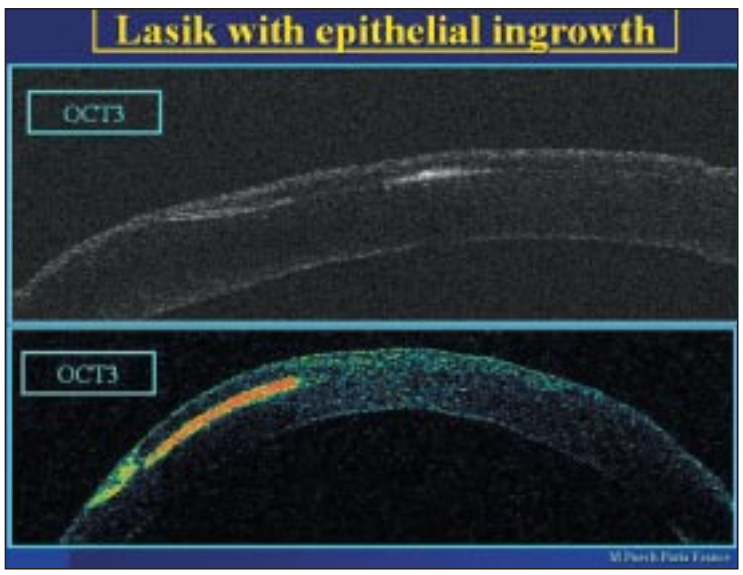
He reported the case of an eye that had undergone penetrating keratoplasty in which OCT3 imaging was able to reveal the junction between the host and donor tissue.

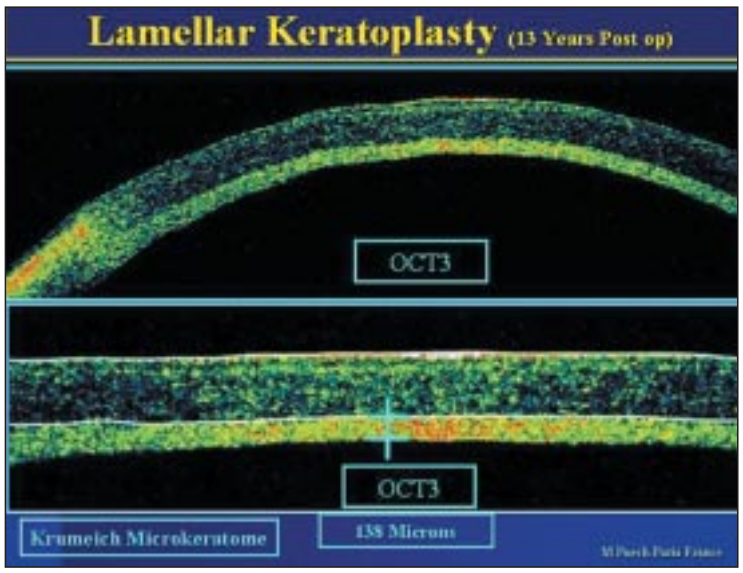




Courtesy of Wolfgang Haigis MD







Courtesy of Michel Puech MD

"This eye had significant corneal oedema, and we were surprised to find that the OCT could pass through the cornea to provide a good image of the posterior surface," Dr Puech observed.

In post-LASIK eyes, it was possible to identify the margin of the flap even four years after surgery. However, Dr Puech acknowledged that 50 MHz ultrasound biomicroscopy (UBM) and very high-frequency digital ultrasound scanning (Artemis 2, Ultralink LLC) provide higher resolution.

"In contrast, in a case of corneal fibrosis post-LASIK, OCT3 was better for observing the reaction on the anterior cornea compared with UBM," he said.

Currently, Dr Puech and colleagues are using the OCT technology in a study involving the femtosecond laser microkeratome (IntraLase FS, IntraLase) to evaluate flaps and compare the attempted and achieved depths in the cornea.

However, he noted that until further advances are made, the OCT3 has more limited uses for studying anterior segment anatomy, as it cannot image the entire segment.

"Using OCT3, it has been possible to observe the reaction of the iris with changes in lighting and to identify iris pathology, such as cysts, melanoma, and nevi. However, the infrared beam does not penetrate behind the iris," Dr Puech said.

He has used the OCT3 to study eyes with anterior chamber and posterior chamber phakic IOLs. In contrast to UBM where it is necessary to reconstruct the images, the OCT3 can be more easily determine distances between the phakic implant and the corneal endothelium and the crystalline lens.

"To study anatomical relationships of anterior chamber phakic IOLs in the angle, however, other techniques, such as VHF ultrasound or UBM, are better suited, and in investigating eyes with posterior chamber phakic IOLs, the OCT3 can only be used to obtain images in the pupillary area, but not peripherally," Dr Puech said.

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