

Advanced anterior segment imaging tools used to explore accommodation

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In Lisbon

NEW anterior segment imaging techniques are helping researchers better understand the anatomic changes that occur during accommodation.

Speaking at the XXIII Congress of the ESCRS, George Baikoff MD presented findings from a study using non-contact anterior chamber optical coherence tomography (AC-OCT, Visante™, Carl Zeiss Meditec) for in vivo measurement of changes in the human crystalline lens during accommodation.

"Anatomic exploration of the anterior segment will become an integral part of our routine practice in the near future as accommodation continues to have a growing role in our activity in refractive surgery. OCT, which was developed many years ago for evaluating the posterior segment, has recently been modified for use in the anterior segment, and it provides one of the easiest ways to explore the anterior chamber during accommodation," said Dr Baikoff, Clinique Monticelli, Marseille, France.

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In order to characterise age-related changes, Dr Baikoff evaluated 104 eyes of 56 patients ranging in age from seven to 82 years old. They had spherical errors between -5.0 D and +5.0 D. The study included only patients with 1.0 D or less of astigmatism.

Different levels of accommodation (0 to 10 D) were stimulated using an optical target that was focused and defocused with negative lenses.

The results showed that maximum achieved subjective accommodation decreased with increasing age. Maximum accommodative amplitude was 10 D in the youngest subjects studied and decreased to about 1.5 D in individuals aged 60 and older.

The AC-OCT studies showed that change was accompanied by an age-related decrease in the

forward movement of the crystalline lens' anterior pole during accommodation. To illustrate that point, Dr Baikoff showed images from a 10-year-old who achieved 10.0 D of accommodation and a 55-year-old with maximum achieved accommodation of 1.75 D. The anterior pole of the lens moved forward by 314 microns in the child versus only 14 microns in the middle-aged, presbyopic patient.

Decreasing AC depth with age

Static measurements obtained in unaccommodated eyes showed that there was an approximate linear decrease in anterior chamber depth with age beginning after age 20. The calculated change was about 18 microns per year of age and was due to increasing thickness of the crystalline lens.

"The age-related decrease in anterior movement of the lens during accommodation is a result of loss of plasticity and provides objective proof of presbyopia," Dr Baikoff said.

The researchers also analysed the radius of curvature of the crystalline lens' anterior pole for

changes during accommodation and relating to age. Those studies showed that the radius of curvature decreased with increasing levels of accommodation (i.e., the lens surface became steeper) and with age, but that the lens lost its ability to modify the anterior capsular curvature as it became older.

"The power of the crystalline lens may change as a result of variation in refractive index and/or the radius of curvature. The observed deformation of the crystalline lens during accommodation means the lens is a very dynamic structure that gains power during accommodation from increased steepness. The older lens loses this capacity, but is thicker and has steepened. However, there is no increase in myopia with ageing, the explanation

for that 'lens paradox' is that there appears to be a change in the refractive index of the crystalline lens substance," Dr Baikoff said.

He also performed measurements in a single albino eye. Since the infrared light of the AC-OCT instrument could be untransmitted through the unpigmented iris, study of that patient allowed imaging of the entire crystalline lens and of the ciliary body. The results indicated the anterior surface of the crystalline lens appeared to be a perfect circle at rest, but varied in curvature during accommodation. In addition, lens thickness was found to increase during accommodation due to what appeared to be forward movement of its anterior pole and posterior movement of the posterior pole.

"These findings need to be considered carefully because they are based on a single eye and require trusting the quality and calculations of the de-warping software. However, the results are consistent with the modifications of the anterior segment described by von Helmholtz 150 years ago," Dr Baikoff said.

Implications for phakic IOLs

He noted that the findings from the AC-OCT study are not simply of interest from a physiological standpoint, but have clinical applications, particularly for planning phakic IOL surgery. For example, the thickening of the lens with age and the forward shift of its anterior pole may explain the potential for contact to occur between the lens and angle-supported or iris-fixated phakic IOLs. Using AC-OCT, Dr Baikoff noted he has also observed touch between the anterior surface of posterior chamber phakic IOLs and the crystalline lens during accommodation, especially in hyperopes.

In addition, inter-patient variation in crystalline lens rise and anterior chamber depth appears to explain why pigment dispersion develops in some eyes implanted with the iris-fixated phakic IOL. Crystalline lens rise is defined as the distance between the anterior pole of the crystalline lens and the horizontal plane joining the opposite iridocorneal recesses. In a previous study, Dr Baikoff found pigment dispersion occurred almost exclusively in eyes with a crystalline lens rise of greater than 600 microns and anterior chamber depth less than 3.2mm.

Accommodation in pseudophakes

In a related presentation, Emilio Pedrotti, MD, of the Eye Clinic, department of neurological and visual science, University of Verona, described his study using two different ultrasound biomicroscopy systems – the UBM 840 (Carl Zeiss Meditec) and the 35 MHz HiScan (Optikon System), to investigate pseudophakic eyes in the relaxed state and during accommodation.

Dr Pedrotti's study included 26 eyes of 23 cataract surgery patients (mean age 75 years) that were implanted with one of four different monofocal IOLs. The measurements were performed prior to surgery and at five to nine months post-implantation.

The results showed cataract surgery induced an increase in the posterior chamber depth and sulcus. In the pseudophakic eyes, accommodation was associated with statistically significant reductions in the sulcus-to-sulcus distance, ciliary ring diameter, sulcus diameter, and iris to ciliary process angle.

"Near vision with monofocal IOLs may be influenced by these changes, because during accommodative stimuli, the optic may move forwards, backwards, or tilt, depending on the position of the IOL relative to the ciliary apex and the relationship between IOL size and capsular bag diameter," Dr Pedrotti said.

A single surgeon performed all surgeries, using the same technique with a clear cornea incision, phaco chop, and no suture closure. All patients were 64 years of age or older. The implanted IOLs were all foldable acrylic but included both hydrophobic (20 IOLs) and hydrophilic (6 IOLs) materials.

Dr Pedrotti reported that in the unaccommodated state, a space was noted between the ciliary process and capsular bag in only about 20% of eyes, while there was no space in the rest. Capsular bag diameter was found to consistently decrease during accommodation. That was demonstrated in the eyes where there was no space between the ciliary process and capsular bag by deformation of the IOL haptics and in the eyes where there was space by disappearance of that gap.

Evaluation of the capsular bag plane near the ciliary process apex showed that the capsular bag plane was coincident to the apex in about 80% of eyes and posterior to it in the remaining 20%.



George Baikoff

Using both technologies to measure change in anterior chamber depth from the relaxed to the accommodated state showed there was a mean decrease overall, but it was modest (HiScan -0.04 mm, UBM -0.03 mm) and not statistically significant.

"However, we found wide variability in our series. In some eyes there was no change while in others the anterior chamber depth increased or decreased. The one consistent observation was that the anterior chamber depth either decreased or remained unchanged in eyes where the capsular bag plane was posterior to the ciliary process apex," Dr Pedrotti reported.

Using the HiScan, he observed statistically significant decreases in the sulcus-to-sulcus diameter and the ciliary ring diameter in response to accommodative stimuli. Measurement of the change in the scleral spur perpendicular to sulcus distance with UBM also showed a statistically significant decrease in the sulcus diameter with accommodation.

The distance between the iris and ciliary process measured with UBM was also found to decrease during accommodation, indicating a decrease in posterior chamber depth. Measurement of the iris to zonular distance with both technologies also showed there was a decrease in mean posterior chamber depth with accommodation, although only the change measured with the Hi-Scan was statistically significant.

"In about 30% of eyes, posterior chamber depth was not changed, but the shape of the posterior chamber was still modified according to the movement of the pseudophakic lens haptics," Dr Pedrotti said.

Using both technologies showed a statistically significant decrease in the iris ciliary process angle (horizontal and vertical) when going from the relaxed to the accommodated state.

"This measurement also shows movement of the ciliary process in a sagittal plane," Dr Pedrotti said.

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