

## THE ACCOMMODATION CLUB

### 6<sup>TH</sup> MEETING

2<sup>nd</sup> May, 2008

Retter Auditorium  
Bascom Palmer Eye Institute  
University of Miami

Supported by:



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## Welcome to The Accommodation Club

The Accommodation Club provides a forum for scientists, engineers, clinical practitioners and developers to discuss and foster research into understanding accommodation and the development of systems to restore accommodative function. Our goal is to provide normal vision at all distances to the enormous number of presbyopic and cataract patients around the world.

We invite you to share your latest findings relevant to the study of accommodation, presbyopia and restoration of accommodation and engage in active discussion during this meeting to further our knowledge in this important area of vision correction.

*Jean-Marie Parel, President*

### Acknowledgement

*The Accommodation Club gratefully acknowledges the generous support provided by the Bascom Palmer Eye Institute, University of Miami Miller School of Medicine, Miami, FL, USA and The Vision Cooperative Research Centre, Sydney, NSW, Australia. Their provision of the venue, audio-visual support, meeting organisation and catering will greatly contribute to the success of this meeting.*

## Meeting Program Outline

**7:00** **Registration**

**7:30** **Introduction & Welcome**

Welcome and Opening Address Prof Eduardo Alfonso, *and*  
Dr Sonia Yoo

Message from the President Jean-Marie Parel

Meeting "Ground Rules" Arthur Ho

*Law & Order* William Culbertson

*Meeting Chair* Sonia Yoo

*Chief Moderator* William Culbertson

**7:50** **Session I & II: Accommodation & Presbyopia**

*Session Moderators:* Paul Kaufman, Ronald Krueger,  
Sverker Norrby, Rob van der Heijde

**9:40** **Morning Break**

**10:00** **Sessions III & IV: Restoring Accommodation**

*Session Moderators:* Melanie Campbell, Jackson Coleman,  
Mary Ann Croft, Philippe Sourdille

**11:50** **Lunch Break**

**13:20** **Sessions V & VI: Lens Growth, LEC & PCO**

*Session Moderators:* Robert Augusteyn, Arlene Gwon, Sonia Yoo

**14:45** **Official Meeting Close**

**15:30** **Tour of Ophthalmic Biophysics Center**

*Hosts:* Jean-Marie Parel, Fabrice Manns

## Abstracts Listing

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## I Accommodation: Basic Understanding

### 1. VOLUME OF THE HUMAN LENS AND SURFACE AREA OF THE CAPSULAR BAG DURING ACCOMMODATION

Hermans EA, Pouwels PJW, Dubbelman M, Kuijer JPA, van der Heijde GL, Heethaar RM

VU University Medical Center, Amsterdam, The Netherlands

**Purpose:** A change in surface area of the capsular bag or a change in lens volume, can indicate whether the change in shape of the lens during accommodation is due to either the compressibility or the elasticity of lens material.

**Methods:** 3D Magnetic Resonance Imaging (MRI) was used to undistortedly image the complete shape of the lens in a group of five healthy subjects between the ages of 18 and 35 years. A parametric representation of the cross-sectional shape was fitted to the edges of the lens, which were determined with a Canny edge filter. Based on a partition of the lens into eight parts, the parametric shape allowed calculation of the cross-sectional area, volume and surface area. Two accommodation stimuli were offered to the subjects in the MRI in order to study the changes with accommodation. Corrected Scheimpflug imaging was used to validate the results obtained with MRI.

**Results:** No statistical difference in central anterior and posterior radius of curvature and thickness was found between the MRI and Scheimpflug measurements. In accordance with the Helmholtz accommodation theory, with increasing accommodation a reduction of anterior and posterior radius of curvature was measured. Furthermore, a decrease of equatorial diameter and an increase of lens thickness were found. Based on MRI, and partition of the lens into eight parts, the mean volume in the group of five healthy subjects was  $160 \pm 2.5$  mm<sup>3</sup> and the volume showed no significant change ( $p=0.9$ ) during accommodation ( $160 \pm 2.7$  mm<sup>3</sup>). However, the mean surface area of the capsular bag showed a significant decrease ( $p=0.04$ ) during accommodation from  $176 \pm 2.8$  to  $168 \pm 2.9$  mm<sup>2</sup>, equivalent to a mean strain of 5.0 %.

**Conclusions:** In the present study, the cross-sectional area of the lens increased with accommodation but no change of lens volume was found. This implies that the internal human lens material can be assumed to be incompressible and is undergoing elastic deformation. Furthermore, the change in surface area indicates that the capsular bag is also undergoing elastic deformation.

Supported by the SenterNovem grant "Young eyes for elderly people" (IS 043081) and Advanced Medical Optics (AMO Groningen B.V.)

### 2. CONTRIBUTIONS OF MOUSE GENETIC BACKGROUND ON ANTERIOR LENS CAPSULE THICKNESS

Brian P. Danysh<sup>1</sup>, Kirk J. Czymmek<sup>1,2</sup>, Pecos T. Olurin<sup>3</sup>, Jacob G. Sivak<sup>4</sup>, Melinda K. Duncan<sup>1</sup>

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4. School of Optometry, University of Waterloo, Waterloo, Ontario, Canada

Many accommodative intraocular lenses in development attempt to take advantage of the viscoelasticity and tensile strength of the lens capsular bag. Both physical traits are determined in part by the

thickness of the capsule. We report anterior capsule thickness measurements for the first time in genetically tractable mice from four inbred strains, BALB/c, FVB/N, C57BL/6, and 129X1, and the outbred strain ICR. We show significant differences in anterior lens capsule thickness between unrelated mouse strains, suggesting capsule thickness is a quantitative genetic trait shared by strains with common ancestry. This leads to the possibility that human lens capsules from different ethnic groups may vary in thickness, thus varying their viscoelastic and tensile strength properties and directly affecting the accommodative effectiveness of an intraocular lens.

### 3. IN VIVO CRYSTALLINE LENS CHANGES DURING ACCOMMODATION IMAGED WITH OPTICAL COHERENCE TOMOGRAPHY

James S Wolffsohn, George A Gibson, Amy L Sheppard, Leon N Davies

Ophthalmic Research Group, Aston University, Birmingham, UK

**Aim:** To investigate the in vivo change in crystalline lens surface positions with accommodation.

**Method:** Thirty-two phakic human right eyes (aged 18-36 years old; average  $19.9 \pm 3.6$  years) were imaged with Anterior Segment Optical Coherence Tomography (AS-OCT, Visante, Zeiss) focusing at accommodative demands of 0D to 4D in 1D steps. Accommodative response to these targets was measured using an open-field autorefractor (NVision-K 5001, Shin-Nippon).

**Results:** A biphasic response was observed, with an increased change in anterior and posterior lens surface positions at approximately 1.2D of accommodative response. Below this level of response, there was no shift in the posterior lens surface position.

**Conclusion:** Crystalline lens shift with accommodation is more complex than is often reported.

### 4. OBJECTIVE MEASUREMENT OF THE AMPLITUDE OF ACCOMMODATION USING WAVE-FRONT TECHNOLOGY

Norberto López-Gil, Vicente Fernández-Sánchez, Francisco Lara, Sergio Bonaque

Grupo de Ciencias de la Visión. Universidad de Murcia, Murcia, Spain.

**Introduction:** We present the main results obtained in the last two years by our group of research, concerning the objective measure of the amplitude of accommodation (AA).

**Methods:** We measured the change of aberrations in 100 eyes using two subjective methods (Push-up and Badal Optometer) and an objective one (using an aberrometer). It has also being study the possible influence of pupil diameter and monocular convergence on the objective measurement.

**Results:** For young subjects there is in general a good agreement between subjective and objective results, but in presbyopic subjects the objective measurements underestimates (about 10%) the AA, probably due to the effect of a larger depth of field in the presbyopic group. Monocular convergence increased the AA between 5 and 8 % (not significant) depending on the degree of convergence.

**Conclusions:** AA could be measured objectively by aberrometry although usually a small underestimation is found. The method could be applied to test objectively new techniques to restore accommodation.

### 5. REFRACTIVE CONTRIBUTIONS OF THE LENS ASPHERIC SURFACES DURING SIMULATED EX VIVO ACCOMMODATION

David Borja<sup>1,2</sup>, Stephen Uhlhorn<sup>1</sup>, Noel Ziebarth<sup>1,2</sup>, Esdras Arrieta-Quintero<sup>1</sup>, Adriana Amelincx<sup>1</sup>, Derek Nankivil<sup>1,2</sup>, Klaus Ehrmann<sup>3</sup>, Arthur Ho<sup>3</sup>, Fabrice Manns<sup>1,2</sup>, Jean-Marie Parel<sup>1,3</sup>

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2 Biomedical Optics and Laser Laboratory, Dept of Biomedical Engineering, Univ. of Miami, Coral Gables, FL;

3 Vision Cooperative Research Centre, Sydney, Australia

**Purpose:** To measure refractive contribution of the aspheric lens surfaces to total accommodative amplitude in monkey lenses during simulated accommodation.

**Methods:** Accommodation simulation experiments were performed on 2 baboon (2 year old) and 4 cynomolgus monkey lenses within 24 hours postmortem. The intact accommodation apparatus, consisting of the lens, capsule, zonules, ciliary body, and sclera was mounted in a lens stretching system (EVAS II) which radially stretches the tissue from the accommodated (zero load) to the unaccommodated state (radially stretched by 2mm). Lens cross-sectional profile was imaged at every step increment with a custom designed OCT system. Lens thickness, anterior and posterior surface curvatures were obtained from digital image processing of the OCT images. Equivalent refractive power was measured with a Scheiner system. The acquired optical and biometric data was used to calculate the refractive contributions of the surfaces at each incremental step of stretching in an optical ray tracing program.

**Results:** Ex vivo accommodation simulation by 2mm of radial stretching decreased the power of the lens and central thickness and increased the equatorial diameter and surface curvatures in these pre-presbyopic monkey lenses. The surface refractive power contributed 42% of total lens power at each accommodative state. Change in surface refractive power contributed to 44% of the total change in lens refractive power.

**Conclusions:** Changes in lens shape and power during simulated accommodation are consistent with the Helmholtz theory of accommodation. These findings show the internal structures of the lens contributes to over half of the power and power change of the lens during simulated accommodation.

Support: 2R01EY14225, 5F31EY15395 (Borja), NSF Graduate Student Fellowship (Ziebarth); Florida Lions Eye Bank; P30EY14801 (Center Grant); an unrestricted grant from Research to Prevent Blindness Australian Federal Government CRC Scheme through the Vision Cooperative Research; the Henri and Flore Lesieur Foundation (Parel).

### 6. A STRUCTURAL MODEL FOR THE LENS CAPSULE FOR USE IN FINITE ELEMENT ANALYSIS OF ACCOMMODATION

Harvey J. Burd

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**Purpose:** To develop a structural constitutive model for the lens capsule, in which the mechanical behaviour of the underlying collagen IV network is explicitly represented.

**Methods:** The collagen is represented by a 2D network of interconnected non-linear filaments. A neo-Hookean material is used to model the surrounding proteoglycan matrix. A study has been conducted to compare a 3-parameter version of the model with previ-

ously-published data on uniaxial (Krag 1998) and biaxial (Fisher 1969 and Pedrigo et al. 2007) tests on the human lens capsule.

**Results:** The model provides a good fit with published data. The general form of the non-linear uniaxial force-stretch response reported by Krag (1998) emerges as a natural consequence of the geometric characteristics of the network used model the collagen.

**Conclusions:** The proposed model provides representations of behaviour that compare well with previous test data. The model is in a form that is suitable for use in finite element studies of accommodation.

#### 7. MORPHOLOGY OF VITREOUS ZONULE

**Elke Lütjen-Drecoll, Paul Kaufman, Mary Ann Croft**

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2. Department of Ophthalmology & Visual Sciences Madison WI USA

UBM-data obtained from Rhesus monkeys of different age groups showed structures next to the pars plana region which could not be explained by our previous descriptions of the zonular system.

Careful preparation of the vitreous membrane showed that there is a complex zonular fiber system connecting the zonular plexus with various portions of the vitreous membrane.

The exact course of these fibers from the vitreous next to the posterior lens capsule towards the most posterior pars plana region will be shown and the functional significance of the system be discussed.

#### 8. THE EFFECTS OF HIGHER-ORDER ABERRATIONS ON DEPTH OF FOCUS AS OBSERVED USING AN ADAPTIVE OPTICS VISUAL SIMULATOR.

**Karolinne Maia Rocha<sup>1,3</sup>, Laurent Vabre<sup>2</sup>, Nicolas Chateau<sup>2</sup>, Jerome Ramos-Esteban<sup>2</sup>, Ronald R. Krueger<sup>3</sup>**

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- 2 Imagine Eyes, Orsay, France
- 3 Cole Eye Institute, Cleveland Clinic, Cleveland, OH USA

**Purpose:** To evaluate the impact of applying individual Zernike coefficients (spherical aberration, coma and trefoil) on depth of focus.

**Method:** The ocular aberrations of 10 normal subjects were measured up to the 10th Zernike order using a crx1 Adaptive Optics Visual Simulator (Imagine Eyes, France) based on a Shack-Hartmann wavefront sensor and an electromagnetic deformable mirror functioning with a closed-loop feedback algorithm throughout the experiment to control the wavefront shape. Subjects' eyes were dilated with 1% Tropicamide to inhibit accommodation and the accommodative response was checked using the same device 15 minutes after the drops were inserted. The crx1 was used to introduce varying degrees of pure Zernike aberrations, including coma (Z(3,-1)), trefoil (Z(3,-3)) at magnitudes of  $\pm 0.3$  and spherical aberrations (Z(4,0)) at magnitudes of  $\pm 0.3, \pm 0.6$  and  $\pm 0.9\mu\text{m}$  through a fixed 6-mm pupil diameter. Depth of focus curves were plotted for each simulated aberration using measurements obtained by displaying 10 Sloan letter optotypes. Each subject's depth of focus was assessed by plotting the number of read letters as a function of the induced defocus.

**Results:** The obtained results show that applying pure spherical aberration coefficients linearly shifts the best point of focus by 1.3 D for each  $0.5\mu\text{m}$  of spherical aberration in the direction of its sign. Simulating spherical aberration equally increased the depth of focus value up to 2D, depending on the sign and the value of its coefficient. This increase reached a maximum before decreasing in the

presence of strong spherical aberration values ( $0.9\mu\text{m}$ ). Trefoil and coma did not appear to shift the best focus point and only slightly changed the depth of focus value.

**Conclusion:** By using adaptive optics based technology for vision simulation, we were able to draw quantitative results on the effects of higher-order aberrations such as spherical aberration, coma or trefoil on the depth of focus of non pathological eyes. Most notably, simulating both positive and negative spherical aberrations significantly improved subjects' overall Visual Depth of Focus (VDoF) when compared to the effects on VDoF observed when introducing coma and trefoil. Spherical aberrations equally appear to increase subjects' best focus point. Our results suggest that spherical aberration should be further studied and incorporated into the design of optical corrections for presbyopia. This has the clinical potential for both in-office patient simulations and for the implementation of adaptive optics into refractive surgery techniques.

## II Ageing & Presbyopia: Basic Understanding

### 9. AGING CHANGES OF THE CILIARY BODY LENS AND POSTERIOR ZONULE IN THE MONKEY EYE

**M.A. Croft, J.P. McDonald, and P.L. Kaufman**

*Dept. of Ophthalmology & Visual Sciences, Univ. of Wisconsin-Madison,*

**Purpose.** We studied the age-related changes in ciliary body, lens and posterior zonule movements in the monkey eye during accommodation.

**Methods.** Twenty-six rhesus monkeys, aged 5.8-27 yrs were studied. Edinger-Westphal (E-W) stimulated accommodation was measured by coincidence refractometry. Ultrasound biomicroscopy and goniovideography were used to measure the posterior zonula, ciliary body and lens equator movements.

**Results.** Forward ciliary body (FCB) movement declined dramatically (51%) with age compared to centripetal ciliary body (CCB) and lens equatorial movements (18% and 28%, respectively). The posterior insertion point of the posterior zonule moved markedly closer to the scleral spur ( $p < 0.05$ ) in the young eyes compared to the presbyopic eyes.

**Conclusions.** With age, the loss in lens centripetal movement may be secondary to the loss in FCB movement during accommodation, while ciliary body function changes may be secondary to the loss in forward movement of the posterior zonule's posterior insertion site.

*Support: NEI (EY10213), RPB, OPREF.*

### 10. ULTRASONIC INVESTIGATION OF THE HUMAN EYE ACCOMMODATION AT PRESBYOPIA.

**Vladimir V Strakhov, Lidia A Mineeva**

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We investigated the crystalline lens, ciliary body, zinni's and the posterior chamber of the eye by means of ultrasonic biomicroscopy (Humphrey UBM, 840) and biometry (A/B Scan Mentor ME) on the 40 volunteers aged 20-25 years and 58 presbyopes aged 40-70 years. Among presbyopes, in comparison with the young patients, together with the involuntal thickness of the lens we indicated the essential decreasing of the orbicular space of the posterior eye chamber up to its transformation into a split kind. The direction of the middle and the posterior zinni's portion changed from the meridional (as in young patients) up to the radial (in presbyopes). We indicated a sheaf down to sagging and a wavy course of the middle

and back portions in the orbicular space of the posterior eye chamber. We connect such essential age changes of the orbicular space of the posterior eye chamber and zinni's tones with the involuntal increasing of the size of the lens that indicates the importance of the reduction of working distance of accommodation between the lens and the serratus line.

It means that the involuntal decreasing of the accommodation volume is connected with the constant increasing of the lens size during life but not only with the lowering its elasticity. This process begins since childhood and finishes at the senile age as a clinically manifestation of the presbyopia.

### 11. THE OPTICS OF ACCOMMODATION, PRESBYOPIA AND ITS CORRECTION

**Melanie C.W. Campbell<sup>1,2,3</sup>, Liam Epps<sup>1</sup>, Donna Strickland<sup>1,2</sup>, Jennifer J. Hunter<sup>4</sup>, Ram P. Sharma<sup>1,5</sup>, Marsha L. Kisilak<sup>1,3</sup>**

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- 3 School of Optometry, University of Waterloo, Canada
- 4 Center for Visual Science, University of Rochester, USA
- 5 Centre for Energy Studies, Indian Institute of Technology, Delhi, India

Our group has experimentally studied the optical quality of the crystalline lens, and has established that the basis of presbyopia development is the ageing changes in the crystalline lens. As well as optical changes in the lens during accommodation and ageing, our studies have focused on the gradient of refractive index (GRIN) within the lens. Our studies suggest that the GRIN distribution has a symmetry more complex than that of a simple spheroidal distribution.

Our experimental measurements have been used as the basis for novel optical models of the crystalline lens and eye. These models in turn allow us to quantify the optical quality on the retina. Results from the phakic eye can be compared in turn to models of presbyopia treatment. These models have given us insight into a potential unintended source of vision improvement in the surgical reversal of presbyopia and the performance of accommodating dual lens IOL's.

Recently we have extended our models of the GRIN within the crystalline lens to consider nonlinear optical properties. We may be better able to control cavitation bubble formation within the lens following the application of fs laser pulses. Currently we are assessing both experimentally and theoretically the role of self-focusing and other nonlinear processes. Initially we have modelled self-focusing within the GRIN of the lens. Our analysis suggests that the GRIN in the crystalline lens produces self-focusing at much lower powers than homogeneous media. This will help to define the pulse and beam profiles required to optimally use fs pulses for a presbyopia cure.

### 12. HOW MUCH RESTORED ACCOMMODATION IS ENOUGH?

**James S Wolffsohn, Sanjay Vakani, Leon N Davies**

*Ophthalmic Research Group, Aston University, Birmingham, UK*

**Aim:** To determine how much of an individual's amplitude of accommodation could be utilised in a sustained reading task.

**Method:** Twenty subjects (aged 18-40 years old; average  $26.1 \pm 4.7$  years), read N5 print at their closest comfortable working distance for thirty minutes, while their eye-to-text distance was moni-

tored. Their amplitude of accommodation was measured with an accommodometer, while accommodative accuracy over a 0D to 4D range was assessed with an open-filed autorefractor (SRW5000, Shin-Nippon) before and after the sustained reading task.

**Results:** Pre-presbyopic patients, regardless of age or residual amplitude of accommodation, are able to sustain  $80.2 \pm 15.6\%$  of their maximum accommodation for prolonged use. Accommodative fatigue following the sustained reading task was minimal as evidenced by no significant decrease in accommodative accuracy ( $p=0.37$ ) and measured amplitude of accommodation ( $F=2.2$ ,  $p=0.10$ ).

**Conclusion:** Presbyopia can be overcome if a combination of the depth of focus (influenced by pupil size and ocular aberrations) and objective accommodation (such as from movement of an intraocular lens on ciliary muscle contraction) can provide one and a third times the accommodative demand of the desired target distance.

### III Restoring Accommodation: Current Technology

#### 13. PASCAL, A WINTER'S TALE AND PRESBYOPIA

D Jackson Coleman

New York Presbyterian – Weill Cornell Medical Center, New York, NY

New research findings have further documented the role of the anterior vitreous in support of the lens during accommodation. Vitreous support is inconsistent with the Helmholtz-type of accommodative mechanism. Vitreous support follows Pascal's Law of Hydraulics, and thus corroborates the anterior lens curvature as a catenary-type suspension. This concept allows simple, straight forward determination of anterior lens curvature based on the ciliary diameter and lens size. Consequently, presbyopia modification procedures and accommodating lenses can be predicted based on precise and accurate measurements of anatomical features.

Presbyopia modification and accommodative lens design benefits from measurements of the lens volume, lens surface area and the size of the ciliary sphincter dimension. New ultrasound techniques including annular arrays and chirp technology are able to measure these dimensions with great accuracy and precision.

#### 14. CRYSTALENS 5-0 RESULTS AT THE BASCOM PALMER EYE INSTITUTE

Raj Rajpara, Chris Hainline, Sonia Yoo

Bascom Palmer Eye Institute, University of Miami Miller Medical School, FL, USA

**Purpose:** To assess the effectiveness of using Crystalens 5-0, the only FDA approved accommodating posterior chamber intraocular lens, for intraocular lens replacement due to cataract extraction.

**Methods:** A scleral tunnel surgical technique was performed. The wound incision size ranged from 3.5 – 3.7 mm. A 5.5 – 6.0 mm capsulorrhexis was performed with the capsule covering the haptics. A suture was placed at the end of the procedure. A chart review was then performed reviewing the pre-operative and post-operative spherical equivalents, uncorrected near visual acuities (UCNVA) and uncorrected distance visual acuities (UCDVA). Posterior chamber opacification and the need for YAG capsulotomy laser treatment were also recorded.

**Results:** The average pre-operative spherical equivalent was -1.09, whereas the average post-operative spherical equivalent was -0.93. The average post-operative UCDVA was 20/40. The average pre-operative UCNVA was 20/40, whereas the average post-operative

UCNVA was 20/35. Five out of the 17 eyes (29%) had posterior capsular opacification (PCO). Forty percent (2 out of 5) of those underwent YAG capsulotomy. There were no intraoperative complications and no eyes needed LASIK for correction of residual refractive error.

**Conclusion:** The use of Crystalens 5-0 for the treatment of aphakia secondary to cataract extraction is a safe and effective procedure for restoring a patient's visual acuity and decreasing the patient's dependence on spectacles. The postoperative PCO rate was 29% in this series of eyes.

#### 15. BINOCULAR PERFORMANCE OF SYNCHRONY AND RESTOR IOL

Scott Evans, Sanjeev Kasthurirangan

Visiogen, Inc

**Purpose:** To compare the binocular performance of Synchrony and Restor IOLs in a randomized study.

**Methods:** Bilateral Synchrony (32 patients) and Restor (33 patients) implantations were performed in a randomized manner. Binocular visual acuities (VA) were measured 4-6 months after surgery at far (4m), intermediate (2m, 1m, 80cm and 60 cm) and near (40cm) distances.

**Results:** Distance corrected VA was significantly different between Synchrony and Restor patients (Two-way ANOVA,  $F_{1,372} = 101.61$ ,  $p < 0.01$ ) with significant interaction effect ( $F_{5,372} = 11.92$ ,  $p < 0.01$ ). Post-hoc t-tests revealed that Synchrony and Restor VA were not different at far (Synchrony vs Restor: -0.11 vs -0.07 logMAR,  $p=0.10$ ) and near (Synchrony vs Restor: 0.17 vs 0.16 logMAR,  $p=0.83$ ) but significantly different for intermediate distances ( $p < 0.001$  for each distance, Synchrony vs Restor for mean intermediate VA: -0.01 vs 0.18 logMAR).

**Conclusions:** Synchrony performance was better than Restor at intermediate distances and comparable at far and near.

#### 16. THE PACT TECHNIQUE (PRESSURE AND ACCOMMODATION RESTORATION BY CILIARY TRANSLOCATION) FOR THE TREATMENT OF PRESBYOPIA

Ronald R. Krueger, Satish Herekar, Peter Meurs

Cleveland Clinic Foundation

**Purpose:** To evaluate the safety and effectiveness of the PACT technique for restoring functional near vision in patients with presbyopia and to outline the proposed mechanisms of action of PACT.

**Methods:** After receiving informed consent, 49 emmetropic, presbyopic patients (mean age 56 yrs, range 43-68 yrs) were treated bilaterally with the PACT technique by a single surgeon (Peter Meurs, Eindhoven, Netherlands). The technique targets a Holmium:Yag laser (Priavision, Menlo Park, CA) transconjunctally onto the sclera ~1 mm posterior to the limbus at 25 mJ/pulse, 20 pulses (5Hz x 4 sec.)/spot and 15 spots (3 rows of 5) in each quadrant. Pre and postop testing includes distance (Snellen) and near (Rosenbaum card) visual acuity, as well as applanation tonometry. Mechanisms of action for the improvement in near UCVA and reduction of IOP are proposed based on an optical simulator of ciliary body position & scleral biomechanics in connection to the near focus quality of vision.

**Results:** Preliminary results in the cohort of 95 treated eyes, having follow-up ranging from 1 day to 11 months, reveals no complications or adverse reactions. The mean preop near UCVA was J9.6

( $\pm 3.9$ ) and improved ~4 lines to J5.2 ( $\pm 3.6$ ) at 1 week or less and J5.4 ( $\pm 3.8$ ) at the last postop visit. An IOP lowering effect was also observed in the PACT-treated eyes, with IOP decreasing from a baseline of 15.4 mm Hg ( $\pm 2.7$ ) to 12.4 mm Hg ( $\pm 2.5$ ) within the first postop week and to 12.8 mm Hg ( $\pm 2.5$ ) at the last postop visit. In a cohort of 22 eyes (11 patients) having at least 6 months followup, the mean near UCVA improved ~6 lines from J9.5 ( $\pm 3.8$ ) to J3.7 ( $\pm 2.7$ ), and from baseline IOP of 16.4 mm Hg ( $\pm 3.3$ ) to 12.6 mm Hg ( $\pm 2.8$ ) at 6 months or later. Analysis of scleral biomechanics data from the optic simulator is in process. Preliminary results during accommodative effort show increased corneal bending, increased lenticular curvature/lens thickness, TM stretching, anterior CBP translocation (recovering lens growth), and effective geometric zonular tension enhanced by translocation. During disaccommodation, a small ACD reduction is counteracted by small LT? reduction to maintain MRSE/UCVA distance.

**Conclusion:** Preliminary anecdotal results indicate that PACT results in rapid (<1 week) restoration of near UCVA and IOP with no apparent safety issues. PACT effectiveness is believed to be most consistent with the "Modified Geometric Theory" of presbyopia (Strenk S, Strenk L, Koretz J). Further study of PACT under a controlled clinical trial is warranted.

### IV Restoring Accommodation: New Technology

#### 17. DEVELOPMENT OF A CILIARY MUSCLE DRIVEN ACCOMMODATIVE IOL

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**Purpose:** To design a ciliary muscle driven accommodative IOL that has a predictable and large range of variable power. The optical quality at different states of accommodation should be comparable to that achieved with a monofocal IOL.

**Methods:** A concept IOL ("Turtle lens") has been designed with a new focus mechanism that could operate within the dynamics of the ciliary muscle. The new focus mechanism contains two freeform lenses that move perpendicular to the optical axis. The Turtle lens has a base power of 21 D and accommodative amplitude of 8 D. The concept design was optically and mechanically optimized for a typical 60-year-old human eye. Silicon prototypes were made to test mechanical performance in pig and human donor eyes using a laboratory lens stretching device that mimics the ciliary muscle action. Changes in focal length during stretching were measured by laser-based ray tracing and a camera system.

**Results:** During stretch experiments the focal length of the Turtle lens changed according to the design for 8 D of accommodation. Theoretical ray tracing showed that the modulation transfer function (MTF) of the Turtle lens in different accommodative states did not deviate considerably from the MTF of a monofocal IOL. However, the optical quality of initial prototypes was affected due to deformation of the silicon lenses during the stretch experiments.

**Conclusions:** In stretch experiments of pig and human cadaver eyes, the results of base power and accommodation were in accordance with the functional design. Therefore, the new focus principle can be used in the development of an IOL that restores accommodative

dition. Both the mechanical and optical design need further optimization to improve optical quality and functionality.

*Supported by the SenterNovem grant IS 043081 and Advanced Medical Optics (AMO Groningen B.V.)*

#### 18. IN VIVO MICRO-MRI TO ASSESS THE ANTERIOR SEGMENT IN RABBIT EYES AFTER LENS REFILLING SURGERY

**Oliver Stachs<sup>1</sup>, Sönke Langner<sup>2</sup>, Thom Terwee<sup>3</sup>, Klaus-Peter Schmitz<sup>1</sup>, Nobert Hosten<sup>2</sup>, Rudolf F. Guthoff<sup>1</sup>**

1. Rostock University, Germany
2. Greifswald University, Germany
3. AMO BV, Groningen, Netherlands

**Purpose:** The aim of the study is to use high resolution anterior-segment imaging to assess the anterior segment in rabbits after lens refilling surgery.

**Methods:** High-resolution magnetic resonance ocular images were acquired (7.1 Tesla) in rabbits after lens-refilling surgery in combination with an intra-operative antiproliferative treatment to prevent LEC proliferation.

**Results:** The spatial arrangement of refilled lenses was visualized by in vivo micro-MRI. In partially filled eyes, the capsular bag and silicon polymer were separated; in completely refilled eyes, the capsule and polymer came in close contact with no visible interface. A different radius of curvature was found between the refilled lens (3 years postop) compared to the crystalline lens of the contralateral eye.

**Conclusion:** Micro-MRI allows in vivo visualization of the anterior segment of rabbit eyes after lens-based refractive surgery. Imaging of the equatorial lens and the retroiridian region without optical distortions opens a particularly wide range of experimental applications.

#### 19. DYNAMIC ASPECTS OF ACCOMMODATION AFTER POLYMER LENS REFILLING

**Henk Weeber**

*AMO Groningen bv, Groningen, Netherlands*

**Purpose:** To investigate dynamic aspects of accommodation after polymer lens refilling, for the case of polymer lens refilling.

**Methods:** In a previous study, a dynamic mechanical analysis (DMA) was performed on 39 human donor lenses. In the current study, DMA was performed on a silicone material that has been used for lens refilling studies.

The DMA results of the human donor lenses as well as the silicone material were converted to a time dependent relaxation modulus.

Subsequently, the time-dependent moduli were incorporated in a finite element (FE) mechanical model of the accommodative mechanism. In the FE model, the lens material was the only dynamic component. The stimulus consisted of an instant pull/release at the distal tip of the zonular fibers. The dynamic changes in refraction were calculated and compared to that of natural lenses.

**Results:** While human donor lenses typically show three Cole-Cole relaxation processes, the silicone material demonstrated only one relaxation process. The modulus of the silicone was equal or smaller and relaxes more rapidly than human donor lenses.

The FE model demonstrated that for human lenses, approximately 80% of the accommodative amplitude was reached within 0.5 seconds. The dynamic accommodative behavior of the FE model with silicone material occurred in approximately the same time frame as

that of natural lenses. During accommodation, the refractive change of the silicone filled lens was slower than the natural lens. During disaccommodation, the refractive change of the silicone filled lens was faster than the natural lens.

**Conclusion:** The change in refraction of a silicone refilled lens during accommodation and disaccommodation occurs in the same time frame of that of a natural lens. These results indicate that the dynamic changes in refraction of a silicone refilled eye are similar to that of the natural eye.

#### 20. ENGINEERING THE LENS WITH AN INJECTABLE OPTICAL SCAFFOLD

**Arlene Gwon, Lawrence Gruber**

*Advanced Medical Optics, Inc.*

**Purpose:** To evaluate lens regeneration with an injectable polymeric optical scaffold following endocapsular lens extraction in New Zealand white rabbits.

**Methods:** Endocapsular lens extraction was performed in New Zealand white rabbits through a 2-3 mm capsulorrhexis in both eyes of 6 New Zealand white rabbits. Following removal of the lens, a silicone plug was inserted into the capsule bag and maneuvered behind the anterior capsulotomy. In one eye a cohesive hyaluronic acid (HA), Healon® OVD, was injected to coat the capsule bag prior to injection of the polymeric scaffold. In the opposite eye, the polymeric scaffold was injected without any other biodegradable material.

**Results:** At the first postoperative visit, the capsule bag and polymeric scaffold were clear in all eyes in both groups. The mild postoperative inflammatory reaction resolved by 2 weeks. By 2 weeks, anterior capsule fibrosis was noted in all eyes in the polymeric scaffold only group. In contrast the anterior capsule remained clear in 4 eyes in the Healon® OVD / polymeric scaffold group. This suggests that hyaluronic acid may have an antifibrotic effect.

Peripheral and posterior capsule lens regrowth surrounding the scaffolds was first noted at day 20 in the polymeric scaffold group only and at day 15 in the Healon® OVD / polymeric scaffold group. Lens regrowth gradually developed in all eyes by day 42 and was generally clear in the anterior and peripheral capsule bag and more opacified posterior to the polymeric scaffold.

**Conclusion:** Lens regeneration surrounding the polymeric scaffolds was observed as early as 15-20 days following endocapsular lens extraction in 3 month old New Zealand white rabbits. Regenerative lens tissue was clear anterior and peripheral and more opaque posterior to the injectable polymeric scaffold.

#### 21. LASER WELDING OF CAPSULAR PATCHES MEDIATED BY GOLD NANORODS: EX VIVO TESTS

**Roberto Pini<sup>1</sup>, Fulvio Ratto<sup>1</sup>, Paolo Matteini<sup>1</sup>, Francesca Rossi<sup>1</sup>, Luca Menabuoni<sup>2</sup>, Ivo Lenzetti<sup>2</sup>, Neha Tiwari<sup>3</sup>, Sulabha K. Kulkarni<sup>3</sup>**

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- 2 U.O. Oculistica USL 4, Prato, Italy.
- 3 Physics Dept., University of Pune, Pune, India

**Purpose:** To demonstrate the suitability of gold nanorods as exogenous chromophores to mediate the near infrared laser welding of capsular tissue, in view of future applications of this technique in lens refilling procedures.

**Methods:** Colloidal gold nanorods of 40 nm length, 10 nm diameter, with a strong optical absorption at about 800 nm, have been synthesised to be used as laser absorbing chromophores in diode

laser welding procedures. Fresh anterior capsular tissues were taken from porcine eyes ex vivo to simulate hetero-transplants of capsular tissue. In a typical experiment, a patch of donor lens capsule was stained with the nanorods and then laid face-down onto the exposed lens capsule of the recipient. Irradiation was performed with 810 nm, 40 ms diode laser pulses, through a fiberoptic hand-piece brought in contact with the outer capsular surface. The welded capsular sandwiches were then prepared for histological examination.

**Results:** Successful and reproducible welding was achieved in the 80-110 J.cm<sup>-2</sup> range of laser fluences, with satisfactory mechanical strength of the weld. Histological analysis showed thermal denaturation and soldering of the endogenous collagen all through the weld sites.

**Conclusions:** Gold nanorods are suitable exogenous chromophores for the laser welding of capsular tissue. They can be potentially used to perform the closure of capsulorhexes in lens refilling procedures, offering high stability and functionalization to target specific connective tissues.

#### 22. LASER PHOTOLENTOTOMY UPDATE

**Raymond I. Myers**

*University of Missouri-St. Louis College of Optometry*

Since proposing laser modification using a laser on the clear, crystalline lens, considerable development has surrounded safe and effective increase in flexure and in modifying shape. Barriers included ultrashort laser self-focusing, small volume removal, correcting treatment-generated hyperopia, and in vitro and animal study limitations. They have been dealt with through theoretical lens and laser treatment modeling using recent lens anatomical refinements and finite analysis modeling. Reported research including at last year's ARVO meeting has postulated and shown regional locations for treatment, a variety of strategies for power and movement modifications, and duplications of earlier studies showing safety and efficacy for flexural and power treatment.

A future of laser photolentotomy exists for correcting presbyopia and other ametropias in a trans-corneal, non-surgical lens modification of the intact eye. The crystalline lens- a comparatively inert tissue which is isolated from other ocular structures, may offer unique possibilities for refractive corrections and other modifications.

#### 23. IMPROVEMENT IN RELATIVE LENS RESISTANCE IN HUMAN CADAVER LENSES AFTER TREATMENT WITH PHOTODISRUPTION LASER FOR PRESBYOPIA

**R. Frey<sup>1</sup>, R T Olmstead<sup>1</sup>, V. E. Teuma<sup>1</sup>, N. Zepkin<sup>1</sup>, G. Gray<sup>1</sup>, R.H. Yeilding<sup>2</sup> and A. Glasser<sup>3</sup>**

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- 2 University of Texas Medical Branch, Austin, TX
- 3 College of Optometry, University of Houston, Houston TX

**Purpose:** To investigate the use of photodisruption laser treatment on the mechanical properties, specifically relative lens resistance (RLR), of the human crystalline lens related to accommodation and

**Methods:** A computer controlled mechanical device (the "squidger") was constructed to apply compression forces to human lenses in culture medium in similar manner to Glasser and Campbell 1998. Human cadaver paired globes between the ages of 55 and 77, less than 48 hours after death were used. One of the paired lenses was used as a control. Two paired lenses were tested in the compression tester by applying 6 steps of 20um dis-

placement with a 10 second interval between steps. One of each paired lens then received laser treatment with a 1064nm wavelength ultrafast laser and 3D scanning system using the same scan pattern. The paired lenses were returned to culture medium and were retested after the treatment bubbles had dissipated.

**Results:** Control lenses changed their RLR by less than 10% while the treated lenses had a post-op relative lens resistance of a factor of 2.5 times less than the pre-op.

**Conclusions:** It has been shown that laser photodisruption is capable of producing significant reduction in relative lens resistance which may impact Presbyopia treatment.

#### 24. FEMTOSECOND LENTOTOMY TO REGAIN ACCOMMODATION ABILITY

**Holger Lubatschowski<sup>1</sup>, Silvia Schumacher<sup>1</sup>, Michael Fromm<sup>1</sup>, Georg Gerten<sup>2</sup>, U. Oberheide<sup>2</sup>, Alfred Wegener<sup>3</sup>**

1. Laser Zentrum Hannover
2. Laserforum Köln e.V.
3. Department of Ophthalmology, University of Bonn

One concept of regaining the elasticity of the crystalline lens tissue is to create microincisions into the nucleus and cortex which act as gliding planes.

We used two different femtosecond lasers with 5 kHz and with 100 kHz repetition rate to cut incisions into the crystalline lenses of human autopsy eyes as well as in porcine (slaughterhouse) and rabbit eyes (in vivo). The treated eyes were analyzed using OCT and histological sections for detection of the cuts. Mechanical changes were analyzed with Fisher's spinning test and a lens stretching device.

Histological sections show limited thermal and mechanical alteration of the interaction zone. The rotation experiments as well as the lens stretching experiments show an increase in flexibility for the treated lenses. No cataract formation on the living rabbit eyes could be observed up to four weeks.

#### 25. FINITE ELEMENT ANALYSIS OF SPECIFIC PHOTODISRUPTION LASER CUTTING ALGORITHMS TO INCREASE ACCOMMODATIVE AMPLITUDE

**V. E. Teuma<sup>1</sup>, G. Gray<sup>1</sup>, R. Frey<sup>1</sup>, J. Kuszak<sup>2</sup>**

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**Purpose:** Finite Element Modeling has been performed on the lens of the eye with and without simulated laser cutting treatments to study the potential effectiveness of such cuts in improving the accommodative amplitude.

**Methods:** FEA models were constructed to allow evaluation of certain cutting algorithms and their relative change in optical power under zonule tension. Three lens models were constructed consistent with the age related changes in the ratio of the Young's Modulus of the nucleus compared to the cortex as shown by Heys, however the absolute values allowed to vary so as to provide the best simultaneous fit of 3 different ages- 35, 45 and 55 years old with targeted values of accommodative amplitude respectively of 4 diopters, 1 diopters and less than 0.5 diopters.

**Results:** The results show that algorithms can be designed to provide increased flattening of more than 3 diopters with the same zonular force. The results show that certain algorithms can provide an increase in the optical power under zonule tension prior to the flattening the lens.

**Conclusions:** FE Modeling has shown that the photodisruption laser cutting algorithms may provide improvements in amplitude of accommodation, however brain adaptation to a new transfer function may be required for effective human Presbyopia treatment.

#### V Lens Growth, LEC & Capsule: Basic Understanding

##### 26. DISRUPTION OF CYTOSKELETON AS A STRATEGY FOR INHIBITING POSTERIOR CAPSULE OPACIFICATION (PCO)

**Paul Kaufman<sup>1</sup>, Baohe Tian<sup>1</sup>, Suresh Jeyalakshmi<sup>2</sup>, Gregg Heatley<sup>1</sup>, Aravind Haripriya<sup>2</sup>, Mark Filla<sup>1</sup>, Veerappan Muthukaruppan<sup>2</sup>**

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2. Aravind Med Res Foundation, Aravind Eye Hosp, Tamil Nadu, India

**Purpose:** Will perturbation of the actin cytoskeleton induced by latrunculin B (LAT-B) or H-7 prevent PCO?

**Methods:** (1) 8 rabbits (16 eyes) underwent phacoemulsification; 8 eyes received LAT-B (5µM in the AC) and 8 received DMSO (0.25%). The rabbits were sacrificed and the lens capsules fixed and photographed. LECs remaining on the capsule were evaluated by cell area measurements. (2) Following sham cataract surgeries w/ donated human eyes, 7 lens capsules were cultured for 4 weeks; 3 received H-7 (300µM) and 4 received BSS. PCO was scored by a 4-point scale.

**Results:** In live rabbits, LAT-B significantly removed ~15% additional LECs from the capsule, compared to vehicle. Cultured human capsules receiving H-7 showed no wrinkling or PCO, while capsules receiving BSS showed apparent wrinkling and diffuse, thick PCO.

**Conclusions:** Pharmacological perturbation of the actin cytoskeleton may inhibit PCO, and may be a strategy for preventing fibrosis/adhesion-induced malfunction of accommodating IOLs.

Support: NIH Grants EY017612 and EY02698, Aravind Medical Research Foundation.

##### 27. A ROLE FOR GROWTH FACTOR ANTAGONISTS IN THE LENS

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3. Vision CRC, Sydney, Australia
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Growth factors, such as FGF play important roles in lens biology, inducing epithelial cell proliferation and fiber differentiation. Growth factor signalling needs to be tightly regulated and this is commonly achieved by specific signalling antagonists, including members of the Sef (similar expression to fgfs) and Sprouty (Spry) families. We have recently identified both Sef and Spry in the lens and have employed transgenic mouse strategies to identify the role these antagonists play in regulating lens cell behaviour. We found these antagonists to effectively block lens fibre cell differentiation, consistent with a block in FGF-signalling. These results are consistent with these antagonists being important negative regulators of lens cell processes, potentially contributing to the maintenance of the lens epithelium. Disruption to the normal expression of these genes may alter the responsiveness of lens cells to growth factors, leading to

aberrant cell proliferation and/or fibre cell differentiation, and subsequent formation of cataract.

#### 28. HOW DO WE REALIZE THE POTENTIAL FOR LENS EPITHELIAL CELLS TO FORM FUNCTIONAL LENS-LIKE STRUCTURES?

**J.W. McAvoy<sup>1,2,3</sup>, M.D. O'Connor<sup>1,2</sup>, Y. Chen<sup>1,2</sup> and F.J. Lovicu<sup>1,2,3</sup>**

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3. Vision CRC, Sydney, Australia.

Posterior capsule opacification (PCO) is a common complication of cataract surgery that is caused by aberrant growth and differentiation of residual lens epithelial cells. Given increases in the incidence of cataract surgery and the growing magnitude of the problem, we aim to devise strategies to promote lens epithelial cells to regenerate structures with normal functional properties and in so doing circumvent aberrant cell behaviour. Lenses from postnatal rats were used to prepare epithelial explants. These were arranged in pairs with the apical surfaces of epithelial cells juxtaposed. Explant-pairs were cultured for up to 43 days in medium containing 50% vitreous humor. Lens-like structures were routinely generated in culture. They were comprised of ordered epithelial and fiber cells that were transparent and because of their curvature had some focusing and magnifying ability. Other studies with transgenic mice indicate that the organization of the lens fiber cell cytoskeleton plays a key role in determining lens curvature. Understanding the molecular basis of these processes is fundamental to devising strategies for promoting lens reconstruction after cataract surgery.

#### VI Cataracts & PCO: Problem and Solutions

##### 29. HOW COULD CORTICAL CATARACTS BE INDUCED BY ACCOMMODATION FORCES?

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2. Department of Ophthalmology, Leiden University Medical Center, University of Leiden, The Netherlands

We evaluated the gross morphology, location, and fiber cell architecture of equatorial cortical opacities in the aging human lens. Using dark-field stereomicroscopy, we photographed donor lenses in toto and as thick slices. In addition, we investigated the details of the fiber cell architecture using fluorescent staining for membranes and by scanning electron microscopy. We then combined our data with data from recent studies on lens viscoelasticity, biochemistry and Scheimpflug imaging.

We found that small cortical and cuneiform opacities are accompanied by changes in fiber structure and architecture mainly in the equatorial border zone between the lens nucleus and cortex. Because the lens cortex and nucleus have different viscoelastic properties in young and old lenses, we hypothesize that external forces during accommodation cause shear stress predominantly in this border zone. Evaluation of Scheimpflug images during accommodation by Dubbelman and co-workers also revealed a sudden change in stretch at the transition between anterior cortex and nucleus. The location of the described changes suggests that these mechanical forces may cause fiber disorganization, small cortical opacities, and, ultimately, cuneiform cataracts. Our hypothesis



would be in line with recent findings by Truscott and co-workers about a two-compartmental organization of the human lens. They found biochemical arguments for a transport barrier developing at a middle age at the cortical/nuclear interface.

### 30. CD44 AND POSTERIOR CAPSULAR OPACIFICATION (PCO)

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While much is known about the later steps of PCO, there can be a long lag time between the surgery and the onset of obvious changes in the lens epithelium. In cancer, alterations in CD44 expression and splicing are involved in EMT, although its role in the lens is unknown. In the normal adult mouse lens, we found CD44 expression only in the lens fiber cells. However, CD44 expression is highly up-regulated in the residual lens epithelium 12 hours following extracapsular lens extraction in mice while the classical lens EMT marker,  $\alpha$ -SMA, is not up regulated until 24-48 hours after lens injury. Preliminary PCR analysis suggests that normal lens fibers express the canonical form of CD44 usually found in normal tissues while the injured lens epithelium expresses the alternatively spliced forms most usually associated with cancer. While CD44 null mice still can develop PCO, it appears that upregulated CD44 expression is an early molecular marker of lens injury responses.

Funded by the Beckman Foundation, Barry M. Goldwater Scholarship, HHMI, and National Eye Institute.

### 31. AN EX VIVO MODEL FOR DRUG-INDUCED SECONDARY CATARACT PREVENTION – EXPERIMENTAL RESULTS WITH DISULFIRAM, METHOTREXATE AND ACTINOMYCIN D

Katrin Sternberg<sup>1</sup>, Thom Terwee<sup>2</sup>, Oliver Stachs<sup>1</sup>, Rudolf Guthoff<sup>1</sup>, Marian Löbler<sup>1</sup>, Klaus-Peter Schmitz<sup>1</sup>

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2. AMO BV, Groningen, The Netherlands

**Purpose:** In restoring accommodation with a lens refilling procedure through a capsulorhexis, a drug pretreatment of lens epithelial cells in the emptied capsular bag could prevent secondary opacification. We developed an ex vivo model for testing of the pharmacological effectiveness of different drugs.

**Method:** Human capsular rhexis specimens from standard cataract surgery were incubated for 5 minutes with Disulfiram, Methotrexate and Actinomycin D dissolved in pure water or embedded in hyaluronic acid. The residual viable and dead cells were differentiated by use of the Live-dead assay.

**Results:** The drug treatment reduced the number of viable cells on the specimens drastically. Actinomycin D was slightly more potent in cell ablation than Disulfiram and Methotrexate.

**Conclusions:** The screening of drugs in the described ex vivo model can help to reduce the number of preclinical studies for secondary cataract prevention. Clinically, safe drug application may be supported by using hyaluronic acid as carrier.

### 32. LONG TERM EFFECT OF ANTIPROLIFERATIVE LENS EPITHELIAL CELL TREATMENT FOLLOWED BY POLYMER LENS REFILLING SURGERY IN RABBITS

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**Purpose:** The objective of the study is pharmacological intervention in polymer lens refilling surgery to prevent secondary cataract.

**Method:** Lens refilling was performed on six eyes of 6 New Zealand white rabbits. In four eyes the empty capsular bag was treated after finishing phacoemulsification with an LEC-treating viscoelastic mixture containing Actinomycin-D (AD)+D,L-Methotrexate (MTX) +Sodium hyaluronate for 5 minutes.

**Results:** All eyes were successfully filled using the developed surgical procedure. No complications occurred during wound healing. Without capsule treatment the first signs of opacification in the ACL rabbit eye are clearly observed 2 weeks post-op, after 6 weeks maximal. All eyes treated with the viscoelastic AD+MTX mixture showed no posterior capsule opacification at 12-months postop and no-to-low PCO 3 years postop.

**Conclusions:** The lens refilling procedure is feasible in rabbit eyes without alterations in the cornea and anterior segment configuration. An LEC treatment with AD+MTX proved to be a valid method to prevent PCO in rabbits.

### 33. OPACIFICATION OF THE CAPSULAR BAG IN PRIMATES AFTER POLYMER LENS REFILLING

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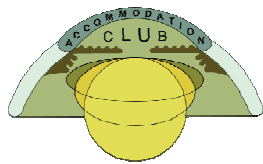
**Purpose:** After refilling the capsular bag of a monkey eye with an injected polymer lens refilling accommodating IOL, a capsular opacification may occur that will negatively influence the accommodating amplitude. The purpose of this study was to demonstrate that this capsular opacification is also dependent on the capsular filling material.

**Methods:** The natural lenses of 3 iridectomized rhesus monkey eyes A, B and C were removed through a 1.5 mm peripheral capsulorhexis and refilled. The capsular bag of monkey A was not pre-treated. The capsular bags of B and C were treated for 5 minutes with a viscoelastic solution in pure water containing Actinomycin-D, with the aim to prevent LEC proliferation. The capsular bags of Monkeys A and B's were filled with a silicone-based in-situ curing pre-polymer mixture. The capsular bag of Monkey C was filled with a viscoelastic sodiumhyaluronate solution (Healon OVD) and closed with a silicone plug. After 3 months the Healon was replaced with the silicone-based material that was used in Monkeys A and B. The clarity of the refilled capsular bags was inspected with a slit lamp. Lens thickness was measured with A-scan.

**Results:** Three months post-operatively the eyes of Monkeys A and B showed clear signs of beginning opacification. The Healon-filled capsular bag of Monkey C showed a good lens shape and no signs of opacification three months post-op. Within 4 weeks after replacing the Healon with silicone material traces of starting opacification could already be detected and refractive changes after pilocarpine-stimulated accommodation decreased from 0.35 mm at 1-month post-op to 0.09 mm at 8 months post-op.

**Conclusions:** With Healon OVD as a capsular filling material in monkey eyes, the LECs did not react. However, when the LECs were in contact with artificial silicone-based lens material, a kind of foreign body reaction was observed.

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