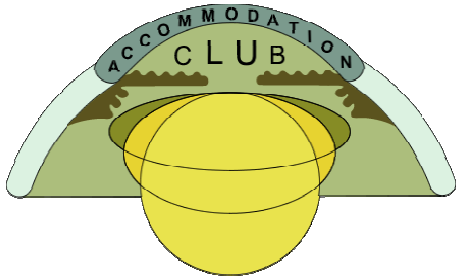

THE ACCOMMODATION CLUB

7TH MEETING

7th May, 2010

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 mission is to promote knowledge that leads to the provision of normal vision at all distances to the enormous number of presbyopic and cataract patients around the world.

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

Jean-Marie Parel, President

Acknowledgements

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, the Brien Holden Vision Institute and the Vision Cooperative Research Centre, Sydney, NSW, Australia. Their provision of the venue, audio-visual support, meeting organisation and catering have greatly enhanced our ability to convene this meeting.

7th Meeting Program Outline

07:00	**Registration**	
07:30	**Introduction & Welcome**	
	Welcome from the President	*Jean-Marie Parel*
	Address from the Meeting Chair	*Philippe Sourdille*
	Official Address from Chairman of BPEI	*Eduardo Alfonso, Chair BPEI*
	Meeting "Ground Rules"	*Arthur Ho*
	Meeting Chair	*Philippe Sourdille*
	Chief Moderator	*Earl Smith*
07:50	**Session 1: The Lens – Anatomy, Physiology, Growth**	
	Session Moderators:	*Jackson Colemann*
		Ronald Krueger
09:00	**Session 2: The Lens – LEC, Cataract, PCO**	
	Session Moderators:	*Arlene Gwon*
		Robert Augusteyn
09:30	**Morning Break**	
10:00	**Session 3: Accommodation – Mechanics & Optics**	
	Session Moderators:	*Susana Marcos*
		Henk Weeber
10:40	**Session 4a: Instruments & Techniques – Imaging**	
	Session Moderators:	*Fabrice Manns*
		Daniel Palanker
11:40	**Session 4b: Instruments & Techniques – Vision**	
	Session Moderators:	*Norberto Lopez-Gil*
		Paul Erickson
12:20	**Lunch Break**	
13:50	**Session 5: Restoring Accommodation: Existing & Imminent Technology**	
	Session Moderators:	*Paul Kaufmann*
		Arthur Ho
14:40	**Session 6: Restoring Accommodation: Existing & Imminent Technology**	
	Session Moderators:	*Adrian Glasser*
		Sverker Norrby
15:40	**Closing Remarks**	*Jean-Marie Parel*
		Philippe Sourdille
	Close	
15:50	**Tour of Ophthalmic Biophysics Center, McKnight Building**	
	Hosts:	*Jean-Marie Parel, Fabrice Manns, Mariela Aguilar*

Abstracts Listing

1: The Lens: Anatomy, Physiology, Growth

Moderators: Jack Coleman, Ron Krueger

1. CLINICIANS ARE ALWAYS RIGHT … AREN'T THEY?

Robert Augusteyn

Introduction: Slit lamp examination reveals alternating dark and light zones in the lens. The central zones have been named the embryonic, foetal, juvenile and adult nuclei, reflecting the growth period in which they were assumed to be produced. The validity of this assumption is examined.
Methods: The dry mass of the different lens zones was calculated from the dimensions and concentration of solids available in the literature and compared with the dry weights of human lenses of known ages.
Results: The dry mass in all of the embryonic, foetal and juvenile nuclear zones was laid down by 2 months prior to birth. The adult nucleus was completed by 3 months after birth.
Conclusions: All of the nuclear zones were produced during the prenatal growth phase and not during the growth periods implied by their assigned names. It is suggested that the nuclear nomenclature be abandoned and the non-specific Oxford nomenclature be adopted.

2. LENTICULAR ACCOMMODATIVE CHANGES OBSERVED AT A LENS FIBER LEVEL WITH CONFOCAL MICROSCOPY

Adrian Glasser, Crystal Corbin, Michael Twa

Purpose: To determine how lens undergoes accommodation at the cellular level.
Methods: Accommodative changes in the lens were measured using 1) ultrasound biomicroscopy, 2) scanning laser optical measurements, 3) confocal imaging , and 4) video microscopy.
Results: Accommodative changes in the lens are quantitatively similar to those that occur in vivo with changes of 12 D of lens power, 600 µm in thickness and 800 µm in diameter. Subtle changes were observed in the lens fiber cells and sutures. Stretching results in general broadening, expansion and elongation and relaxation results general thinning and shortening of the lens fibers cells and sutures.
Conclusion: Accommodation in the monkey lens is accompanied by a subtle, uniform elastic molding of the lens fiber cells by the capsule to decrease fiber diameters and fiber lengths with no spaces, separation, overlapping of the lens fiber end terminals occurring at the sutures.

3. VITREOUS ZONULE (VZ) AND CILIARY BODY: ACCOMMODATION AND PRESBYOPIA IN MONKEYS AND HUMANS

Mary Ann Croft, Jared P McDonald, Paul L Kaufman

Purpose. Compare the human and monkey eye with respect to the ciliary body and zonular attachments at rest and during accommodation and their age-related changes.
Methods. Analogous ultrasound biomicroscopy images were collected in six human subjects (19-53 yrs) and eight rhesus monkeys (5-27 yrs). Accommodation was measured by coincidence refractometry in the monkey during Edinger-Westphal stimulation and in the human during pharmacological stimulation.
Results. There was accommodative forward movement of the ciliary muscle and VZ posterior insertion zone in the young but not older human eye, and the VZ did not stretch during accommodation, similar to the monkey eye. Nasal vs. temporal asymmetries were more marked in the monkey vs. the human eye, possibly due to the higher amplitude of accommodation and concomitant convergence and lens positioning in the monkey.
Conclusions. There is pronounced age-related loss in forward ciliary body movement in the older human eye, which may be a factor in accommodating IOL function.

4. ADRENALINE THE INDUCED IMPELLENT ACTIVITY OF THE CILIARY'S BODY CROWN

Vladimir Strakhov, Lidia Mineeva, Elena Gulidova

We investigated an impellent activity of the ciliary´s body crown by means of ultrasonic biomicroscopy (Humphrey UBM, 840) on the 30 volunteers aged 20-22 years on the medicamental models of a various tone of accommodation. And besides in one eye we instillate drops of 1% solution of pilocarpine and 1% solution of adrenaline in to the other eye. Up to instillation of medicines it was spent control UBM research.
A traditional reaction of the ciliary body on the instillation of 1% solution of pilocarpine has been notised: narrowing of a pupil, approach of the ciliary´s body crown to the crystalline len´s equator and a relaxation of zinni's tones up to a wavy course at the distance from a ciliary´s body crown up to preequator place of an attachment of a crystalline lens.
After instillation of 1% of a solution of adrenaline at all examined has been notised: expansion of a pupil, displacement of a ciliary´s body crown to an iris root, due to which the distance from the crystalline len´s equator up to a ciliary´s body crown increased. At that anterior zinni's portion stretched at maximum, flatting a forward surface of a crystalline lens with increase of radius of curvature, in average, on 0,9±0,21 mm. The discovered impellent activity of the ciliary´s body crown at instillation of 1% of a solution of the adrenaline, with the result of the expansion of the ciliary ring and to a tension of the copular device of a crystalline lens, can be considered as impellent foundation of an active accommodation of a person´s eye for distant vision.

5. MORPHOLOGIC INDICATION FOR PROPRIOCEPTION IN THE HUMAN CILIARY MUSCLE

Paul Kaufman, Cassandra Flügel-Koch, Winfried L Neuhuber, Elke Lütjen-Drecoll

Purpose. To search for proprioceptive nerve terminals in human ciliary muscle.
Methods. In 48 human donor eyes, histologic and ultrathin sections of the ciliary muscle were studied. Immunohistochemical staining was performed.
Results. Calretinin-immuno-reactive (CIR) nerve terminals surrounded the posterior and reticular ciliary muscle tips and their elastic tendons. Terminals in that region contained mitochondria and neurofilaments. At the anterior tips larger terminals with numerous membrane- filled vesicles were located between the muscle fibers. The most elaborate network of CIR nerve fibers was present in the ground plate covering the circular muscle portion and CIR neurons with morphologic features of mechanoreception were present. Within the circular muscle portion numerous CIR ganglion cells were found. Their processes were connected to the CIR network but also surrounded ciliary muscle cells and NADPH-diaphorase-positive ganglion cells.
Conclusions. There are proprioreceptors in the ciliary muscle and the presence of the numerous intrinsic nerve cells indicates that contraction of the circular muscle portion can be modulated locally via a self-contained reflex arc.

6. INFLUENCE OF PHARMACOLOGICALLY STIMULATED ACCOMMODATION ON ANTERIOR CHAMBER PRESSURE IN RHESUS MONKEYS

Lin He, Mark Wendt, Adrian Glasser

Purpose: To evaluate the effect of accommodation on transient IOP changes in anesthetized rhesus monkeys.
Methods: 5 iridectomized adolescent monkeys were anesthetized, with their heads held upright and facing forward in a head holder. Accommodative responses were stimulated by intravenous pilocarpine 0.25-2 mg/kg over 30 seconds and measured with continuous 60 Hz infrared photorefraction. A 27-gauge sterile needle was inserted into the anterior chamber to record IOP.
Results: Transient changes in IOP associated with accommodation were observed in 4 of 5 monkeys. One of the pilocarpine stimulated monkeys showed a decrease in IOP from 0.26 to 0.43 mmHg, independent of the bolus doses. Another monkey had an IOP increase of 0.58±0.12 mmHg with the same bolus dose.
Conclusions: Pharmacologically stimulated accommodation does not cause reliable and consistent changes in anterior chamber pressure. Therefore, changes in IOP cannot be fundamental to the accommodative mechanism.

7. EFFECTS OF OSMOTIC AND MECHANICAL FORCES ON THE SHAPE OF RABBIT AND COW LENSES

Oscar Candia, Rosana Gerometta

Mammalian lenses reversibly change shape, and possibly volume, during accommodation. Isolated lenses change shape in anisotonic media. How the lens changes its shape when its volume is changed osmotically is not established. It could swell or shrink evenly in all directions, or asymetrically. Using methods we developed for determining shape and volume, it was found in isolated rabbit and cow lenses that the anterior and posterior poles length (A–P length) increases under hypotonic conditions, with smaller, or no changes, in equatorial diameter (ED). Thus, the volume increase and the lens became rounder. In hypertonic solutions the lens also became rounder (due to a decrease in ED) as its volume decreased. As such, the lens has a tendency upon swelling to change its shape by approaching the structure of a globular spheroid (as occurs during accommodation for near focusing), but lens shrinkage does not result in a flatter lens with a reduced A–P length as occurs for distance focusing. Moreover, osmotically evoked shape changes appear irreversible, in contrast to the mechanically elicited shape changes of accommodation.

2: The Lens: LEC, Cataract, PCO

Moderators: Arlene Gwon, Bob Augusteyn

8. EMT VERSUS ELSCHNIG PEARLS: WHAT CONTROLS THE DIFFERENCE

Melinda Duncan, Yan Wang

Purpose: After cataract surgery, a substantial percentage of patients develop posterior capsular opacification due to a combination of lens epithelial cell proliferation and cell migration coincident with epithelial-mesenchymal transition (EMT) and lens fiber cell differen-

tiation (Elschnig Pearls). However, little is known about the molecular determinates of whether lens cells remaining in the capsular bag differentiate into lens fiber cells or myofibroblasts. This study seeks to map the molecular pathways leading to these to phenotypic outcomes

Methods: Lens fiber cells were removed from wildtype three month old mice and the profile of EMT and fiber cell markers was determined in the remaining cells in the capsular bag at various times after surgery by immunofluorescence.

Results: The expression of lens fiber cell markers (such as Prox1, cMaf and HMNG3) is found in distinctly different cells than those expressing alpha smooth muscle actin in this mouse model of cataract surgery. Further, some lens fiber cell markers (such as HMGN3) whose expression does not turn on in lens fiber cells until mid-way through fetal development also is expressed later in PCO cells than other, earlier markers of fiber cell differentiation.

Conclusions: Lens epithelial cell populations entering the EMT or fiber cell differentiation pathway appear to distinct in this model of cataract surgery which may imply that the cells remaining in the capsular bag after cataract surgery have distinct regenerative potentials.

9. THE ROLE OF AV-INTEGRIN IN POSTERIOR CAPSULAR OPACIFICATION

Fahmy Mamuya, Yan Wang, Melinda K Duncan

Purpose: Integrins are hypothesized to plays significant roles during the lens epithelial-mesenchymal transition (EMT) that leads to Posterior Capsular Opacification (PCO). However, the identity and function of the integrins participating in this process is poorly understood. The aim of this project is to study the role of αV integrin during lens development as well as during the EMT that occurs after lens surgery/injury.

Methods: Mice harboring a floxed αV-integrin allele were mated with mice expressing CRE in all lens cells (MLR10). At three months of age, fiber cells were surgically removed from mutant and wildtype control lenses and the extent of EMT was measured 48 hours later by immunofluorescent detection of EMT markers.

Results: Lenses lacking αV-integrin subunits are transparent but weigh significantly more than wild type lenses. Electron microscopy analysis revealed slight irregularities in αV integrin knockout's fiber cells ball-and-socket interdigitations. When challenged with surgery/injury, LECs expressing αV-integrin subunits showed an increase in LEC multilayering with upregulation of αSMA 48hrs post surgery. In contrast, LECs lacking αV-integrin subunits showed no increase in LEC multilayering with little to no upregulation of αSMA 48hrs post surgery.

Conclusions: These results suggest that αV-integrins may not be vital players in lens development but are involved in the EMT mechanism that leads to posterior capsular opacification.

10. BLOCKING TGF-BETA-INDUCED EMT AND CATARACTOGENESIS

Frank Lovicu, Hailey Shin, Seonah Jee, Michael L Robinson, Albert Basson, Gail Martin, John W McAvoy

Cataract is characterised by an epithelial-to-mesenchymal transition (EMT). TGF-ß can induce this EMT, disrupting the lens epithelium, leading to cataract. Maintenance of normal lens architecture is achieved by growth factors, such as FGFs, and their respective receptor-mediated signaling pathways. Members of the Sprouty (Spry) and Sef families are negative regulators of such pathways. Sef, Spry1 and Spry2 are expressed in the lens, primarily in the lens epithelium. Conditional deletion of Spry1, or Spry1 & 2 results in cataract formation, similar to that induced by TGF-ß. Consistent with this we now report that deregulation or loss of Spry is associated with aberrant activation of TGFβ signaling (increased labeling of pSmad2 and Snail) in lens epithelia compared to wildtype lenses. Based on this we hypothesise that Spry and/or Sef overexpression will prevent or reduce TGF-ß-induced EMT, hence cataract formation. We show that Spry overexpression can block TGFβ-induced cataract formation in situ. This suggests that Spry may play a protective role for the normal lens epithelium, by regulating the signaling pathways required for its maintenance. Spry may thus serve as a putative therapeutic agent for the prevention of EMT, hence cataract, in situ.

3: Accommodation: Mechanics & Optics

Moderators: Henk Weeber, Susana Marcos

11. COMBINED OPTICAL/MECHANICAL MODELLING OF THE HUMAN EYE

Harvey Burd, Dominic O'Brien, Rupert Robinson

Purpose: To develop a combined optical/mechanical finite element model of the eye for the study of accommodation and the development of presbyopia.

Methods: Previous finite element models of the accommodating lens (e.g. Burd et al. 2002) have typically adopted a relatively simple optical modelling approach based on a uniform lens refractive index. The current project is concerned with a more detailed optical modelling procedure in which a finite element mechanical model of the lens is coupled with a non-paraxial optical analysis of the whole eye. The optical model of the lens is based a GRIN field that is assumed to distort during the accommodation process. These distortions are computed directly from the finite element model. The computed GRIN fields and lens outlines, at different states of accommodation, are imported into a whole-eye optical model that is implemented in the ray tracing program ZEMAX.

Results: Some preliminary results will be presented.

12. EX-VIVO MEASUREMENTS OF ZONULAR ELASTIC PROPERTIES AS A FUNCTION OF AGE IN A COMPUTER CONTROLLED DEVICE FOR SIMULATION OF ACCOMMODATION

Ralph Michael, Marek Mikielewicz, Rafael I Barraquer

Purpose. To measure the elastic properties of the human lens zonules.

Methods. Based on previous designs by Fisher, Glasser, Campbell and Parel our device consists of a rigid bench for holding and stretching coronal eye sections including the ciliary-lens zone. Circumferential stretching is created by a stepper motor coupled to a digital outside micrometer for linear displacement and distance measurement, and a digital balance for load measuring. This is attached to the specimen through 8 Prolene sutures. One web cam is placed above to monitor the coronary diameter changes. We measured six presbyopic eyes from human donors ageing 60, 70, 73, 73, 83 and 89 years.

Results. Preliminary results showed that zonular elongation by 500 µm produced a load of about 10 mN and 1000 µm of about 23 mN, relatively independent of age. Zonular elongation by 2000 µm yielded a load of 80 mN at 60 years and decreased with age to 55 mN at 89 years. Exact stress-strain calculations are under preparation. (10 mN = 1.02 g)

Conclusions. Under physiological conditions, the elastic properties of the zonular apparatus appear not to change with age. However, with extreme elongation, we found a decrease with age.

13. CONTRIBUTION OF LENS REFRACTIVE INDEX GRADIENT TO ACCOMMODATION

Fabrice Manns, David Borja, Bianca Maceo, Derek Nankivil, Stephen Uhlhorn, Esdras Arrieta-Quintero, Arthur Ho, Jean-Marie Parel

Purpose: To determine if the refractive index gradient of the primate crystalline lens contributes to accommodation amplitude.

Methods: Changes in shape and total power of 8 baboon lenses (5.4-8.3 years) and 8 cyno lenses (6-8.4 years) were measured during simulated accommodation in a lens stretcher. The contribution of the gradient was calculated by plotting the total power change (in D) as a function of the curvature change (in D). The experimental results were compared to a paraxial optical model of the lens with continuous gradient.

Results: There is a linear relationship between power change and curvature change, which suggests that the relative contribution of the gradient to total lens power remains constant. The slope of the power-curvature relation was independent of age.

Conclusions: A given change in lens shape produces the same change in lens power independent of age and accommodative state.

14. AUTO-REFRACTION MEASUREMENT OF CONSENSUAL ACCOMMODATION IN UNSIGHTED EYES

Pesala Veerendranath, Les Donovan, Mukesh Taneja, Qian Garrett, Stephanie Delgado, Virender Sangwan, Arthur Ho

Background: Consensual and direct accommodation are generally assumed to be equal although it can differ from direct response in certain conditions. However, there is a paucity of reports on auto-refractors used in unsighted eyes. The objective of this study is to measure the accommodation in unsighted eyes when accommodation is elicited in their fellow sighted eye.

Methods: Ninety-three unilaterally blind subjects (9 to 62 years) were enrolled in the study. Subjects had sufficiently clear ocular media for auto-refraction and can steadily fixate targets with the sighted eye. Accommodation was induced by instructing subjects to fixate on an N8 target for near and a 4/40 letter for distance measurements. A Shin-Nippon NVision- K5001 auto-refractor was used to measure the refractive state in both eyes in the unaccommodated (4 m) and two accommodated states (40 and 33 cm). The difference between distance and near spherical equivalent refractions for each eye was taken as the accommodation response. The same test was conducted on 100 normal-sighted subjects using IR-pass filters to simulate one unsighted eye.

Results: Difference in accommodation between eyes was analysed by linear mixed model including target distance, sightedness and average accommodation as factors. Only non-presbyopes were entered into the analysis. The unsighted eye of unilaterally unsighted subjects showed greater accommodation response than the filtered eye of normal-sighted subjects (p=0.003). Difference between unsighted/filtered eye and sighted eyes increases with increasing average accommodation response (p=0.009)

Conclusion: In unilaterally blind subjects without apparent accommodative system abnormalities, the accommodation response in the unsighted eye is slightly higher than the sighted fellow eye.

4a: Instruments & Techniques – Imaging

Moderators: Fabrice Manns, Daniel Palanker

15. ACCOMMODATION AND PSEUDOACCOMMODATION MEASURED WITH OPTICAL COHERENCE TOMOGRAPHY

Mukesh Taneja, Virender Sangwan, Pesala Veerendranath, Preetam Kumar, Debarun Dutta, Tamal Chakraborty

Purpose: To utilize Optical Coherence Tomography (OCT) to measure changes in the Anterior Chamber Depth (ACD) in phakic and pseudophakic subjects on accommodation stimulus in physiologic conditions.
Methods: A total of fifteen subjects (six phakic and nine pseudophakic) in pre-presbyopic age group and presbyopic age group were subjected to ACD measurement under emmetropic conditions and subsequently under an accommodative stimulus of 3 Diopter using Zeiss Visante OCT. Of the nine pseudophakic patients, three had Polymethyl methacrylate (PMMA) Intraocular Lenses (IOL) and other six had acrylic foldable IOLs.
Results: The results were analyzed and correlated as function of age and type of IOL used. Among the phakic subjects, the anterior lens movement was documented as decrease in ACD and was found to be inversely related to age. However, no significant lens shift was observed in the pseudophakic subjects, irrespective of age or type of IOL used.
Conclusion: Accommodation amplitude was found to be inversely related to age, as expected. However, no pseudo-accommodation could be observed in pseudophakic subjects.

16. ACCOMMODATION DYNAMICS USING CUSTOM DEVELOPED QUANTITATIVE HIGH SPEED OCT IMAGING

Susana Marcos, Enrique Gambra, Sergio Ortiz, Pablo Pérez-Merino, Michalina Gora, Maciej Wojtkowski

Purpose: To quantify the morphological changes in the crystalline lens during accommodation.
Methods: A high resolution, high speed custom-built spectral-OCT was used to image the anterior segment of the eye. 3-D images of the cornea and the crystalline lens were acquired for every accommodative demand (from 0 D to 6 D in 1-D steps). In addition, cross-sectional images of the lens were acquired at 14 Hz to study its fluctuations. Images were corrected from fan and optical distortion using custom-built 3-D ray tracing algorithms. Corrected surfaces of cornea and lens were fitted to retrieve their radii of curvature. Fluctuations of the lens surface position and lens thickness were estimated from the standard deviation of the mean for each steady state. One subject participated in this study.
Results: The anterior and posterior lens surface radii of curvature changed by 3.54 mm and 1.37 mm respectively in the 0-6 D stimuli range. Fluctuations of the anterior and posterior surfaces ranged from 15.3 µm to 19.6 µm. Lens thickness fluctuations ranged from 3.52 µm (0 D) to 4.02 µm (6 D).
Conclusions: High-speed, high resolution, extended axial range sOCT, provided with distortion correction algorithms allows quantitative imaging of the crystalline lens during accommodation.

17. SPECTRAL DOMAIN OCT FOR IMAGING THE CRYSTALLINE LENS AND CILIARY BODY IN VIVO

Jianhua Wang, Meixiao Shen, Lele Cui, Michael R Wang

Purpose: To develop a method using two spectral domain optical coherence tomography (OCT) devices for simultaneously imaging the crystalline lens and ciliary body in vivo.
Methods: A long scan depth (7.2mm) spectral domain OCT at 830nm was synchronized with another spectral domain OCT at 1310nm for image the anterior segment of the eye.
Two scanning probes were used to scan the eye. One probe was mounted on a slit-lamp and placed in front of eye for imaging the anterior chamber depth or the lens thickness.
The other probe was positioned on the limbus of the temporal side for imaging the ciliary body through the sclera. Two healthy eyes were imaged.
Results: With the long scan depth OCT, the entire anterior chamber and the crystalline lens were imaged successfully in separated image session. Due to the limitation of the scan depth, both anterior chamber and crystalline lens can not be imaged at one time (Figure 1). During accommodation, the anterior chamber was shallower and the front surface of the lens appeared to be steeper. With the 1310nm OCT, the ciliary body showed contraction during accommodation (Figure 2). The mess and maximum thickness of the ciliary body showed increases during accommodation.
Conclusions: We have demonstrated the feasibility using spectral domain OCT devices with both 820nm and 1310nm for imaging the anterior segment of the eye including the crystalline lens and ciliary body. It appeared that the method could be used to study accommodation and presbyopia. Further development will be focused on the implementation of the fast CMOS camera with phase-shift technique for super long scan depth. Image registration and calibration will be also needed.

18. ANTERIOR AND POSTERIOR LENS IMAGING AND CURVATURE ANALYSIS WITH THE ARTEMIS 3

Jackson Coleman, Ronald H Silverman, Harriet Lloyd, Dan Z Reinstein

Imaging of the human lens and zonule has been significantly improved with a new ultrasound system called the Artemis3. The anterior zonular extension through the ciliary processes to insertion in the suprachoroidal lamina can be traced. The anterior and posterior capsule shape and position can be measured during accommodation. Prediction of intraocular lens position (ELP) can be improved due to imaging of both the anterior and posterior lens capsules.

19. SIMULTANEOUS MEASUREMENT OF WAVEFRONT AND SHAPE OF THE CRYSTALLINE LENS DURING ACCOMMODATION

Georg Gertin, Claudia Großer, Heike Hoffmann, Maria Büttner, Holger Lubatschowski, Stefan Altmeyer, Uwe Oberheide

Purpose: Proof of principle for a System to correlate morphologic changes of the crystalline lens with changes of the total wavefront due to accommodation.
Methods: A near-infrared OCT-device (SL-OCT, Heidelberg Engineering, Germany) was coupled with an open view aberrometer (iTrace, Tracey Technologies, USA). Both measuring paths were adjusted collinear to measure at the same time the wavefront of the total eye as well as the shape of the crystalline lens at different stages of accommodation. To increase the pupil diameter without influencing the accommodation process eye drops (Neosynephrine 5%) were applied.
Results: The design of the instrument allowed determining the shape of the crystalline lens with its curvatures and thickness as well as the actual wavefront of the total eye at one time. The measured part for curvatures was limited by the achieved pupil diameter. Due to the concept of the iTrace aberrometer with free field of view both measurements of wavefront and lens shape could be performed for deaccommodated state while fixating a far target as well as for accommodative states using near targets at different distances.
Conclusions: The first measurements of this novel system show the potential to correlate changes in wavefront to direct morphologic changes of the lens during accommodation.

4b: Instruments & Techniques - Vision

Moderators: Norberto Lopez-Gil, Paul Erickson

20. PROOF OF CONCEPT OF A NEW DEVICE FOR THE CLINICAL TESTING OF DISTANCE CORRECTED READING ACUITY UNDER FULLY STANDARDIZED CONDITIONS

Gunther Grabner, Alois K Dexl, H Schlögel, M Wolfbauer, Max Rasp, Melchior Hohensinn, T Rückl, Wolfgang Riha

Purpose: To develop a new device for testing distance corrected reading acuity under standardized circumstances. To assess the usefulness of the SRD-adv for different clinical situations, such as after implantation of the AcuFocus Corneal Inlay (ACI) and after a variety of multifocal intraocular lenses (m-IOL).
Methods: The determination of reading performance still is the most important clinical examination, whenever the potential benefits of surgical procedures for the correction of presbyopia or after implantation of mf-IOLs are compared. A comparison of the results of different centers cannot be easily performed without adequate test methods and meticulous standardization.
As measuring reading acuity with fixed distance does not allow to draw conclusions on the "every day reading ability" of patients, the continuously changing reading distance is monitored by stereophotometry, and is mathematically taken into consideration.
The reading angle (=inclination of the display), as an additional variable parameter, can be chosen freely by the patient, to offer the most convenient test circumstances.
Based on the "Radner-Reading-Charts", the SRD-adv was developed for testing reading acuity under different luminance levels (5-100 cd/m2) and in addition different contrast levels by the implementation of a high-resolution computer-display (0,16 mm pixel-interspace) in the original SRD prototype. All currently commercially available reading charts are using high contrast levels (approximately 85-95%). The added feature of testing with different, especially reduced contrast levels (as an example a "normal" newspaper has only about 40-60% of contrast) will probably allow to discriminate even smaller differences regarding every day reading abilities.
The SRD-adv was tested under a variety of clinical situations, such as after ACI- and mf-IOL implantation.
Results: Testing for validity and reliability has been performed with 924 single measurements in distances between 15 and 63 cm, and reading angles between 60° and 90°. Based on the Radner Reading Charts an error range between logRad ±0,0034 at 63 cm and logRad ±0,0143 at 15 cm has been found (this represents no clinical relevance).
With the use of the SRD-adv is has been possible to clearly demonstrate the increase in depth of focus after unilateral ACI implantation

and significant differences in reading performance when three different mf-IOLs were tested under standardized conditions in a clinical study.
Conclusions: With the SRD-advanced it is possible to obtain objective, valid and comparable results as far as the true "reading abilities" of patients are concerned. This encompasses reading acuity, reading speed and critical print size, under different contrast and luminance levels, and subjectively convenient reading distance. Study results that tested reading acuity following a variety of surgical methods are presented.

21. OPTICAL IMAGE QUALITY DURING ACCOMMODATION

Norberto López-Gil, Larry N Thibos, Vicente Fernandez-Sánchez, Robert Montés-Micó

We studied the changes of the average optical quality during accommodation in a large population.
We applied three optical quality metrics: PFSt, STD, VSOTF on the wavefront obtained in 70 eyes (ages between 20 and 45) during the full range of accommodation under natural pupil conditions.
Young subjects with small or negligible lag in most of their accommodation range, have their maximum image quality for intermediate accommodation states (1.5-3 D). The main factors that affect the optical quality during accommodation are: the defocus produced by the accommodative lag (usually for large accommodation stimulus); the decrease of the aberrations caused by the accommodative myosis; and the decreases of spherical aberration.

22. EXPANDING DEPTH OF FOCUS (DOF) WITH INDUCED ABERRATIONS AND VARIABLE PUPIL SIZE

Alexandra Abdala, Glauco Reggiani, Nicolaus Chateau, Laurent Vabre, Ronald Krueger

Purpose: To determine the patient specific aberration pattern and magnitude that maintains good distance visual acuity while expanding depth of focus following cycloplegia in prepresbyopic and presbyopic patients.
Setting: Refractive Surgery Department, Cole Eye Institute, Cleveland Clinic, Cleveland, Ohio, USA.
Methods: Adaptive optics, Crx1 visual simulator is used to correct and introduce 3rd and 4th order aberrations (inferior coma, negative and positive spherical aberrations) from a magnitude of 0.3 – 0.9□m, added in 0.1□m increments to a maximum value while maintaining VA 20/20. After determining the maximum tolerable aberration value, at a dim illumination conditions with a mean pupil size of 5.5 mm, the DoF is tested with a mean pupil size of 3 mm at steps of 0.5D to the maximum DoF range while maintaining 20/20 visual acuity.
Results: Studies expanding DoF by adding high order aberrations have been previously published with a fixed pupil of 6 mm and 20/50 letter size. The importance of this study is to improve the DoF and clinical relevance by using a smaller pupils and a 20/20 letter size. Our early results show that when reducing the pupil size the expansion of DoF is greatest using negative spherical aberrations with a magnitude of 0.5-0.6µm, gaining an additional 1D, in comparison to a bigger pupil size.
Conclusion: Adaptive optics visual simulator can help us evaluate the exact magnitude of aberration needed to improve the DoF while maintaining an acceptable distance visual acuity of 20/20.

23. IMPACT OF PATIENT'S SPECIFIC PUPIL SIZE ON EXPANDING DEPTH OF FOCUS WITH NEGATIVE SPHERICAL ABERRATION USING ADAPTIVE OPTICS VISUAL SIMULATOR

Glauco Reggiani Mello, Alexander Abdala, Nicolaus Chateau, Laurent Vabre, Ronald Krueger

Purpose: The aim of this study is to evaluate the impact of the patient's specific pupil size in bright and dim light conditions on the visual acuity and depth of focus using different magnitudes of negative spherical aberration induced by an adaptive optics simulator.
Setting: Refractive Surgery Department, Cole Eye Institute, Cleveland Clinic, Cleveland-OH, USA.
Methods: The subjects will have their pupil measured in bright and dim light conditions and examined following cycloplegia with the Crx1 visual simulator (Imagine Eyes, Orsay, France). The device will first correct the patient's¬ aberrations, and then induce progressively increasing magnitudes of negative spherical aberration (0.3 – 0.9µm, in 0.1µm steps) while the patient is tested with a 20/20 VA letter size. Finally, the Depth of Focus (Dof) is tested in steps of 0.5 D using the magnitude of negative spherical aberration that obtains the best distance visual acuity while setting the device to the patients' specific pupil size in bright light (reading) conditions as determined by the pupillometry.
Results: Previous studies have shown that inducing negative spherical aberration is one of the better choices for improving the DoF. This study is the first to evaluate the influence of the patient's specific pupil size on DoF. The results can help to choose which patients would be more suitable to receive treatments that induce negative spherical aberration for the purpose of expanding the DoF. The magnitude of negative spherical aberration that can balance good distance VA with improved DoF will also be evaluated.
Conclusion: Knowing the influence of the patients' specific pupil size while inducing negative spherical aberration and the best magnitude of that aberration will enhance the clinical selection of patients who would best respond to laser vision correction for presbyopia.

5: Existing & Imminent Technology

Moderators: Paul Kaufman, Arthur Ho

24. A DEPTH OF FOCUS INLAY TO CORRECT PRESBYOPIA (ACUFOCUS CORNEAL INLAY, ACI)

Gunther Grabner, Alois K Dexl, Orang Seyeddain, Melchior Hohensinn, Wolfgang Riha, Gerhard Nix, T Rückl, Max Rasp

Purpose: To test the AcuFocus Corneal Inlay (ACI) under standardized clinical conditions in a prospective, controlled three-year follow-up study at a single centre.
Methods: The ACI is a 10 micron thick (newer version 5 micron) disc-shaped device (outer diameter 3.8 mm, inner diameter 1.6 mm) that is implanted in the mid-stroma of the cornea in the line of sight of the non-dominant eye. Two different techniques are currently evaluated: the implantation under a flap (170 microns depth) and in a pocket (200-300 microns depth), both created with the help of the Intralase fs-laser. Reading acuity, reading speed and reading distance were evaluated with the Optec 6500P Vision tester and the Salzburg Reading Desk (SRD).
Results: A total of 32 non-dominant eyes of 32 patients (aged 45 to 60 years) were implanted with the ACI and followed for three years. No ACI had to be explanted in this series. The postoperative follow-up was uneventful except for one epithelial in-growth that could be surgically resolved and two cases of ACI-decentration that were recentered 6 month following the initial implantation and improved dramatically both with the UCDVA and UCNVA. All patient basically retained the distance VA within one line and were on average at Jg2 reading acuity, an improvement of 5 lines in average. With the help of the SRD-adv is has been possible to clearly demonstrate the increase in depth of focus after unilateral ACI implantation as well. Examination of the chamber angle and the fundus were easily possible after implantation, as was the assessment of the optic nerve head, the retinal thickness and the visual field that only showed only a minimal, clinically not noticeable decrease in sensitivity.
Conclusions: The AcuFocus Corneal Inlay (ACI) is a new device that seems to improve uncorrected reading acuity in presbyopia to a level useful in daily life, rendering the patients basically spectacle independent under high contrast conditions. Although no ACI had to be explanted in this early series, the potential reversibility (as shown at some other sites) appears to be an added benefit. It is easy to implant for the refractive surgeon and studies are currently under way to assess its usefulness after LASIK and in pseudophakic patients.

25. IMPLANTED CAPSULAR BAG ANATOMICAL PRE-REQUISITES FOR ACCOMMODATION

Philippe Sourdille

Purpose: to analyze sizing and potential movements of an implanted capsular bag.
Methods: 30 human eye bank eyes and 26 cataractous patients had their lens removed and replaced by different IOLs (eye bank eyes) or a one piece acrylic hydrophobic one piece IOL (cataractous patients). Caliper measurements (eye bank eyes) and high frequency ultra sound (cataractous eyes) were used to compare pre and post-operative sizing and position of the capsular bag. We compared these results to those of a new hydrophobic acrylic design supposed to improve adaptability of a given IOL diameter to different capsular bag sizes (Miyake Apple views).
Results: Most one diameter IOLs enlarged and/or ovalized the capsular bag and suppressed the preexisting capsular bag equator - ciliary ring distance. In one third of cases both IOL optics and haptics were situated behind the ciliary apex, precluding any convenient zonular traction. As compared to these results the new design experimentally (Miyake Apple views) showed a significant non capsular bag enlarging.
Conclusion: Anatomical pre requisites for accommodation suppose precise sizing and placement of the implanted capsular bag in the ciliary apex plane to permit adequate zonular traction.

26. EFFECTS OF CHROMATIC ABERRATION, DECENTRATION AND CORNEAL ASTIGMATISM ON THROUGH FOCUS PERFORMANCE OF PREMIUM IOLS

Len Zheleznyak, Myoung-Joon Kim, Scott MacRae, Geun-young Yoon

Purpose: Accommodating and multifocal premium IOLs (PIOLs) are intended to extend pseudophakic depth-of-field (DoF). Our aim is to measure the effects of chromatic aberration and corneal astigmatism on retinal image quality (RIQ) and DoF of PIOLs in vitro.
Methods: An optical bench system was developed to measure through focus image quality of a poly- and monochromatically illuminated USAF resolution target through a model eye. The model eye consisted of a wet cell with a Gullstrand-model artificial cornea (0.085□m spherical aberration for 4mm pupil) and an IOL mounted

with decenter capability. Ophthalmic trial lenses were placed before the artificial cornea to simulate corneal astigmatism (up to 1.0D) and varying object distance (up to 5.0D). PIOLs examined were the aspheric accommodating Bausch and Lomb Crystalens HD (CHD), and the aspheric diffractive multifocals Alcon ReSTOR 3D (RST) and Tecnis ZM900 (TCN). The AcrySof SN60AT spherical monofocal (ASF) served as a control. All IOLs had 20D power and were tested with a 4mm pupil. RIQ was determined by measuring the contrast of images of the USAF target at spatial frequencies of 30 and 15 cycles per degree (cpd), corresponding to 20/20 and 20/40 Snellen letter sizes, respectively. DoF was defined as the dioptric range with RIQ at 15cpd greater than 50% of peak RIQ for ASF.
Results: ASF had the best RIQ but was limited to distant vision (0 to 1.0D). CHD extended its DoF by 30% compared to ASF. Multifocal IOLs sacrificed distant RIQ (60% of ASF) for extended DoF with the addition of near vision, however they lacked intermediate vision.Chromatic aberration had a detrimental effect on RIQ for all lenses. RST and TCN were impacted less than ASF and CHD due to their inherently lower RIQ at distant vision. For up to 700□m decentration, changes in RIQ of white-light images for all IOLs were insignificant. Corneal astigmatism also reduced RIQ for all IOLs. DoF was not decreased with astigmatism up to 0.25D for TCN, although RIQ at 15cpd decreased by 5%. DoF was not decreased with astigmatism up to 0.5D for ASF (35% RIQ decrease), CHD (28% RIQ decrease) and RST (4.% RIQ decrease). With corneal astigmatism larger than 0.5D, DoF for PIOLs did not significantly differ from that with ASF.
Conclusions: The benefit of extended DoF with PIOLs is absent in the presence of corneal astigmatism larger than 0.5D. The uncorrected corneal astigmatism in pseudophakic patients can affect through focus performance of PIOLs and needs to be compensated to maximize their efficacy.

27. THE INNOVIA FOLDABLE ACCOMMODATING LENS

Len Pinchuk, Marcia Orozco, Yonghua Zhou, Yongmoon Kwon, John B Martin, Saul Gottlieb, Ysushi Pedro Kato

There are several new accommodating lenses commercialized or in clinical trials around the world that function upon the principles of forward-back motion, dual optics or deformation of a sulcus placed lens. The forward-back motion lenses suffer from small dioptre changes; the others require large clear corneal incisions. The larger the incision, the more inflammation, the higher the risk of corneal endothelial cell damage, astigmatism, and the longer the pain and healing time. There is a need for a large dioptre change accommodating lens that can be placed through a small corneal incision.
The Innovia Lens, consists of a lens made from a soft polyisobutylene-based gel with a high index of refraction (>1.5). The 10% modulus of elasticity of the lens is less than 290 KPa with a tensile strength of 240-290 KPa and elongation at break of 500-800%. The fully polymerized and shaped lens is injected into the lens capsule through a < 2.4mm diameter cannula. The haptics are sized to approximate the equator of the lens capsule.
The notched haptics are integral with the lens and contain a raised lip to allow the lens capsule to shrink around it to essentially grip it. It is hypothesized that tension or compression of the lens capsule by means of the ciliary muscles/zonules system will cause the lens to expand radially outward or contract radially inward thereby changing the radius of curvature of the lens with an accompanying dioptre change.
The extent of dioptre change was measured by placing the lens in the center of an open ring, a suture was sewn into each of the eight haptics, the suture was draped over the ring and a 1g weight attached to the opposite end of the suture. The dangling weights caused the lens to stretch radially outward. The dioptre was measured relaxed and under tension by focusing the lens on a US Air Force Grid target. The change in dioptre loaded versus unloaded was found to be approximately 3.5 dioptres for the total of 8g weight.

28. OCT-GUIDED FEMTOSECOND LASER FOR CATARACT SURGERY

Daniel Palanker, Neil J Friedman, Mark S Blumenkranz, Juan Batlle, Rafael Feliz, Jonathan Talamo, Dan Andersen, Georg Schuele, George Marcellino, William Culbertson

Purpose Cataract surgery is a manual procedure highly dependent on the surgical skills and complicating factors. We created a system including Optical Coherence Tomography (OCT) and fs laser to improve the precision and reproducibility of cataract surgery.
Methods A long range OCT automatically discerned the anterior and posterior surfaces of the lens and cornea for planning of capsulotomy, lens segmentation and corneal incisions using co-registered scanning fs laser. Cutting parameters were established on cadaveric eyes, and retinal safety was verified on rabbits. 20 patients have undergone cataract surgery using the fs laser system. Eyes were examined ophthalmoscopically, and extracted capsules were analyzed using histology and SEM.
Results The OCT was able to identify the cornea and lens surfaces within 50□m. Round (aspect ratio > 0.98) and highly precise (less than ±0.1mm in diameter) capsulotomies were achieved. Histology and SEM of incised capsules showed smooth, clean edges. Lens segmentation facilitates its easy splitting into quadrants and nucleus softening improves its aspiration. Even dense cataracts (3.5) could be removed with minimal use of phaco power. Multi-planar corneal incisions provide for unique self-sealing wound constructions. The treated eyes were immobilized by suction without amaurosis. No retinal damage or other laser-related adverse events have been observed.
Conclusions OCT-guided femtosecond laser greatly improves precision and reproducibility of cataract surgery. The laser produces sharp-edged continuous capsular cuts, while lens treatment simplifies its segmentation and phacoemulsification, especially with dense cataracts. This integrated system offers a previously unattainable level of exactitude that promises improved centration of IOLs and correction of residual corneal astigmatism.

6: Novel & Future Technology

Moderators: Adrian Glasser, Sverker Norrby

29. FEMTOSECOND-LENTOTOMY: LASER TREATMENT OF THE CRYSTALLINE LENS FOR ACCOMMODATION RESTORATION

Holgar Lubatschowski, Michael Fromm, Tammo Ripken, Ole Massow, Heike Hoffmann, Mario Simons, Uwe Oberheide, Silvia Schumacher, Alfred Wegener, Georg Gerten

Purpose: During the development of presbyopia the ability of deformation of the lens is decreasing, while ciliary muscle, zonular fibres and lens capsule stay mainly active. In order to regain accommodation femtosecond laser pulses induced micro incisions are implemented into the crystalline lens which act as gliding planes during accommodation.
Methods: The gliding planes were generated into human donor lenses and extracted primate lenses as well as into rabbit lenses in vivo with a 100 kHz fs-laser system. Optomechanical and geometrical changes of the lens due to the fs-lentotomy treatment were analyzed with the Fisher spinning test and a lens stretching device. Furthermore the laser induced changes of the crystalline lens and the retina of living rabbit eyes were analysed using OCT, Scheimpflug imaging and histological sections up to six months postoperatively.
Results: The lenses sustained an increase in accommodation amplitude after the laser treatment. The follow up examinations have shown a fading in the visibility of the micro incisions. In addition, no tissue changes with respect to cataract formation were recorded in any of the treated lenses.
Conclusion: Ultrashort near infrared laser pulses might be an interesting tool to induce micro incisions inside the crystalline lens with the aim to regain accommodation ability

30. SHORT PULSE LASER DISRUPTION OF THE CRYSTALLINE LENS FOR ACCOMMODATION RESTORATION

Ronald Krueger, Harvey Siy Uy, Randy Frey

Purpose: To outline the recent advancements and early clinical experience of short pulse laser use in the crystalline lens for accommodation restoration.
Methods: Early research showing safety and potential efficacy of laser accommodation restoration has led to complex computer based finite element modeling of lens function and laser disruption. Based on preliminary studies in Mexico City, 5 presbyopic subjects (age range 50-60 years) in the Philippines with BSCVA >20/40 and < grade 2 NS underwent unilateral laser disruption of lens nucleus using a central sparing algorithm.
Results: The mean age was 56 +4 years and the mean nucleus density was 1.25 +0.5 grade. Two weeks after the procedure, the vision was stable with no change in mean logMAR BCVA and full resolution of bubbles inside the lens. The mean logMAR UCNVA and BDCNVA showed improvement in 1 +1 lines (range 1-3 lines) and 2 +1 lines (range 1-3 lines), respectively. Four of the 5 subjects reported subjective improvement with an ability to see cell phones and reading material. Only one reported no subject improvement despite reading 1.5 lines better.
Conclusion: Short pulse lasers have the potential to improve near vision in presbyopic subjects. Although objective tests of accommodation were not performed in this cohort, further studies with objective testing are anticipated in an effort to demonstrate a lens based method of restoring accommodation in presbyopic eyes.

31. RESTORATION OF ACCOMMODATIVE RESPONSE VIA MICRO-VOLUMETRIC REMOVAL OF TISSUE IN THE MID-PERIPHERY OF THE CRYSTALLINE LENS

Valas Teuma, Gary Gray, Steve Bott, Randy Frey

Purpose: The purpose of the study is to explore the utility of using a femtosecond laser to restore accommodative capacity through removal of micro-volumes of crystalline lens tissue, in custom shapes designed to increase the anterior lens curvature in the mid-periphery in the accommodated state. The curvature would then decrease under zonular tension for distance vision.
Methods: Finite Element Analysis was used to generate models of human lenses representing subjects of ages 35, 45 and 55 years old. The models were used to predict refractive change and accommodative response when micro-volumes of tissue of specific shapes were removed from the mid-periphery of the modeled lens. A femtosecond laser was programmed to deliver custom shot patterns designed to remove lens tissue in a manner mimicking that of the

shapes predicted by the FEA to generate the highest accommodative response. Laboratory testing was conducted on porcine eyes to compare the changes in anterior lens curvature resulting from application of the custom shot patterns with the FEA prediction. The same custom shot patterns were applied in clinical trials to human subjects with refractive changes measured subjectively and objectively.
Results: FEA predicts refractive power increases of 3.5 D and 3.6 D, respectively, for the 45 YO and 55 YO presbyopic model eyes. The change for a 35 YO normal eye was much smaller: 2 D. The femtosecond laser-treated porcine eyes showed an average 1.5D increase of refractive power. Clinical treatment of the eyes of human subjects with the same custom patterns resulted in significant increases in refractive power measured both subjectively and objectively.
Conclusions: Finite Element Modeling predicts that femtosecond lasers can be used to change anterior lens curvatures by volumetric removal of tissue in the mid-periphery of the lens and further predicts an accommodative response when the treated model lens is subjected to zonular tension. Femtosecond lasers applying custom patterns to porcine lenses and to eyes of human subjects resulted in increases in refractive power in reasonable agreement with the FEA predictions.

32. BIOCOMPATIBLE PATCHES FOR LASER-INDUCED CLOSURE OF CAPSULORHEXES IN LENS REFILLING PROCEDURES

***Roberto Pini*, Paolo Matteini, Francesca Rossi, Fulvio Ratto, Luca Menabuoni, Ivo Lenzetti**

Purpose: To demonstrate the possibility to realize a laser-welded flap-valve of biocompatible films on a capsulorhexis in order to perform lens refilling procedures.
Methods: Films of biopolymeric materials can be proposed for the closure of capsulorhexes, as alternatives to synthetic materials like silicone and glues. Chitosan patches, shaped like disks of 30-50 micron thickness and 2 mm diameter were synthesized. For the laser-absorbing chromophore, we considered: 1) Indocyanine Green (ICG); 2) gold nanorods (GNRs), with optical absorption at 810 nm. Tests we carried out ex vivo on freshly enucleated pig eyes. A 1-2 mm diam. rhexis was created on the anterior capsule and then the chitosan patch was placed to close the rhexis. Laser irradiation was performed around the edge of the patch by means of 810 nm, 100 ms diode laser pulses. Histological analysis of the welded capsular tissue was executed.
Results: Successful and reproducible laser-induced closure of capsulorhexes was achieved with both ICG-loaded and GNR-loaded chitosan films. In addition, the technique enabled the creation of a temporary flap-valve which facilitated the lens refilling with no dispersion of the filler in the A.C.
Conclusions: We demonstrated ex vivo effective laser-induced closure of capsular tissue by the use of easy-handling chitosan patches, which may find applications in lens refilling procedures.

33. DEVELOPMENT OF A MECHATRONIC SYSTEM TO RESTORE HUMAN ACCOMMODATION

***Oliver Stachs*, Ulrich Gengenbach, Rudolf F Guthoff, Georg Bretthauer**

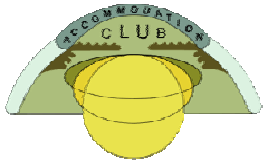
Introduction: Mechatronic systems are a new approach to restore the accommodative ability of the human eye. This contribution describes an autonomous approach using recent developments of micro- and nanotechnology.
Methods: A concept for a mechatronic accommodation system was developed consisting of a sensor system for acquisition of accommodation demand, active optics, control/communication unit as well as energy supply and assembled into an integrated system for implantation into the capsular bag. The requirements for this artificial accommodation system and first results for the different subsystems are described and discussed.
Results: A functioning optical demonstrator device scaled 5:1 was realized and demonstrates the interaction between the subsystems: active optics (cubic optical lens system) and sensor system for acquisition of accommodation demand (vergence angle). The next generation prototype is currently being developed in 2:1 scale, integrating new active optics, sensor system, control unit and energy supply.
Conclusions: The mechatronic accommodation system could be a new way for restoring the human accommodation. First steps have been done to design and manufacture the single subsystems. However, strong efforts must be undertaken to realise such a complex system in target size.

34. ADVANCES IN TISSUE ENGINEERING THE LENS

***Arlene Gwon*, Lawrence Gruber**

Purpose: To evaluate lens regeneration with a biodegradable or non-degradable injectable polymeric scaffold for engineering replacement lenses 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 New Zealand white rabbits. Following removal of the lens, a collagen patch was inserted into the capsule bag and maneuvered behind the anterior capsulotomy. In one group of eyes hyaluronic acid (HA) was injected as a biodegradable scaffold. In another group of eyes, HA was injected prior to injection of a nondegradable polymeric scaffold.
Results: At the first postoperative visit, the capsule bag and biodegradable or non-degradable scaffolds were clear in all eyes. The mild postoperative inflammatory reaction resolved by 2 weeks. The collagen patch dissolved by 2-3 weeks and lens regeneration was first observed in the peripheral capsule bag at 2 weeks in both groups. Lens regeneration progressively filled most of the capsule bag by 3 months in the biodegradable scaffold group and approximately 20% of the capsule bag in the nondegradable scaffold group. In the biodegradable scaffold group, the regenerated lenses were spherical with a clear cortex of good structure. The nucleus was slightly opaque and spheroid in most lenses and filled approximately 20% of the central lens area. In the nondegradable scaffold group, lens regrowth was generally clear in the anterior and peripheral capsule bag and slightly more opaque posterior to the nondegradable scaffold.
Conclusion: Lens regeneration was facilitated by implantation of a biodegradable or nondegradable scaffold in NZ white rabbits.

The Accommodation Club



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