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Abstract Book

October 13-14, 2017
State Room · Boston · USA

Course Director:
Joan W. Miller, MD (USA)

Faculty:
David Brown, MD (USA)
Karl Csaky, MD (USA)
Christopher Girkin, MD (USA)
Frank G. Holz, MD (Germany)
Don Hood, PhD (USA)
Alex Huang, MD (USA)
Glenn Jaffe, MD (USA)
Christian Mardin, MD (Germany)
Mark Nelson, MD (USA)
SriNivas R. Sadda, MD (USA)
Giovanni Staurenghi, MD (Italy)
Robert N. Weinreb, MD (USA)

Guest Speakers:
Christine Curcio, PhD (USA)
Francois Delori, MD (USA)
Massimo Fazio, PhD (USA)
Ari Green, MD (USA)
Kourosh Nouri-Mahdavi, MD (USA)
Osamah Saeedi, MD (USA)

Program Committee:
Joan W. Miller, MD; Deeba Husain, MD; John B. Miller, MD
Mass Eye and Ear and Mass General Hospital, Boston, USA
### Scientific Program

**Course Director:**
Joan W. Miller (USA)

**Program Committee:**
Joan W. Miller, Deeba Husain, John B. Miller
Mass Eye and Ear and Mass General Hospital, Boston (USA)

**Faculty & Guest Speakers:**
David Brown (USA), Karl Csaky (USA), Christine Curcio (USA), Francois Delori (USA),
Massimo Fazio (USA), Christopher Girkin (USA), Ari Green (USA), Frank G. Holz
(Germany), Don Hood (USA), Alex Huang (USA), Glenn Jaffe (USA), Christian Mardin
(Germany), Mark Nelson (USA), Kouros Nouri-Mahdavi (USA), Srinivas R. Sadda (USA),
Osamah Saeedi (USA), Giovanni Staurenghi (Italy), Robert N. Weinreb (USA)

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Saturday, October 14, 2017

08.00  Welcome Coffee

Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO) – Moderators: Srinivas R. Sadda, Francois Delori

08.30 FLIO Introduction and Applications in Alzheimer’s Disease (Srinivas R. Sadda) – page 53

08.50 Assessing Changes in Macular Telangiectasia Type 2 (Lydia Sauer) – page 55

09.00 Monitoring Carotenoid Fluorescence (Paul Bernstein) – page 57

09.10 Drusen in Age Related Maculopathy (Martin Zinkernagel) – page 59

09.20 Retinal Imaging in Neurological Disease (Ari Green) – not available

09.35 Panel Discussion – Moderator: Srinivas R. Sadda, Francois Delori

09.45 Coffee Break & Scientific Market with Posters

Rapid Fire: OCT Angiography – Moderators: Glenn Jaffe, Giovanni Staurenghi

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10.45 Imaging the Deep Choroidal Vessels (Demetrios G. Vavvas) – page 63

10.55 OCTA Helps Defining Details of CNV on HS-ICG (Karl Csaky) – page 65

11.05 Colocalization of In-Vivo Mechanical Strain and Ocular Perfusion (Massimo Fazio) – page 67

11.15 Macular Pigment (Giovanni Staurenghi) – page 69

11.25 Ischemic Optic Neuropathies (Eric Gaier) – page 71

11.35 Age-Related Macular Degeneration (Mark Nelson) – page 73

11.45 Ultra-High Resolution Cross-Sectional OCT Angiography of Retinal and Choroidal Neovascularizations (Marco Lupidi) – page 75

11.55 Posterior Uveitis (Lucia Sobrin) – page 77

12.05 Macular Telangiectasia Type 2 (Zaria Ali) – page 79

12.15 Panel Discussion – Moderator: Glenn Jaffe, Giovanni Staurenghi

12.25 Boxed Lunch Delivery

Lunch Symposium: Glaucoma 2 – Moderators: Don Hood, Christian Mardin


12.50 First Data of OCTA in Glaucoma (Christian Mardin) – page 83

13.00 New Morphometric Biomarkers for Glaucoma in the Deep Optic Nerve Head (Christopher Girkin) – page 85

13.20 Misconceptions about OCT and Glaucoma (Don Hood) – page 87

13.40 Panel Discussion – Moderator: Don Hood, Christian Mardin

13.50 Closing Remarks – Joan W. Miller / Stephan Schulz

14.00 END

Poster Presentations:

Characterization of Retinitis Pigmentosa Using Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO) (Karl Andersen) – page 89

OCT: An Evolving Role in Neuro-Ophthalmology in South Africa (Marissa Willemse) – page 91

Optical Coherence Tomography Retinal Segmentation Changes Induced by Gradual Ascent to High Altitude in Mountaineers Randomized to Acetazolamide vs. Placebo (Mariano Cozzi) – page 93

Multimodality Imaging in Oncology (Marco Pellegrini) – page 95

Diabetic Choroidopathy with Swept-Source Optical Coherence Tomography (Rebecca Silverman) – page 97
Course Director:

Joan W. Miller, MD
Mass. Eye and Ear and Mass General Hospital, Harvard Medical School, Boston, MA, USA

Joan W. Miller, MD, FARVO, is the David Glendenning Cogan Professor of Ophthalmology and Chair of the Department of Ophthalmology at Harvard Medical School, and Chief of Ophthalmology at Massachusetts Eye and Ear and Massachusetts General Hospital. Dr. Miller earned her medical degree and received her ophthalmology residency training from Harvard Medical School, and then completed fellowships in ophthalmology research and vitreoretinal surgery at Mass. Eye and Ear. In 2003, Dr. Miller became the first female physician to achieve the rank of Professor of Ophthalmology and the first woman to serve as Chair of the Department of Ophthalmology at Harvard Medical School. She is also the first woman appointed as Chief of Ophthalmology at both Mass. Eye and Ear and Mass. General Hospital.

An internationally recognized expert on retinal disorders, Dr. Miller is credited with developing verteporfin photodynamic therapy (PDT), the first pharmacologic treatment for age-related macular degeneration (AMD); co-discovering the importance of vascular endothelial growth factor (VEGF) in intraocular disease; and demonstrating the therapeutic potential of VEGF inhibitors in neovascular eye disease. Dr. Miller continues to elucidate the pathophysiology of vision loss and develop improved therapies for retinal disease. Her current investigations focus on genetics of AMD, strategies for early intervention in AMD, and neuroprotective therapies for retinal disease.

Dr. Miller has authored more than 200 original research articles and nearly 80 book chapters, review articles, or editorials. She a member of the National Academy of Medicine, the Academia Ophthalmologica Internationalis, and is a Gold Fellow of Association for Research in Vision and Ophthalmology (ARVO). Among her numerous honors, Dr. Miller delivered the 2012 Edward Jackson Lecture for the American Academy of Ophthalmology, and was a co-recipient of the 2014 António Champalimaud Vision Award, the highest distinction in ophthalmology and visual science. In 2015, Dr. Miller became the first woman to receive the Mildred Weisenfeld Award for Excellence in Ophthalmology from ARVO.
Deeba Husain, MD
Mass. Eye and Ear, Harvard Medical School, Boston, MA USA

Deeba Husain, MD, completed her medical training at Jawaharlal Nehru Medical College, Aligarh, India. She then pursued a research fellowship with Evangelos Gragoudas, MD, and Joan W. Miller, MD, at Mass. Eye and Ear, Harvard Ophthalmology. Following completion of her ophthalmology residency training at Harvard Medical School and a fellowship in vitreoretinal surgery at Mass. Eye and Ear, Dr. Husain joined Boston University School of Medicine in 2003, where she directed the Retina Service and the Retina Fellowship Training Program. She joined the faculty at Harvard Ophthalmology in 2013, and is now an Associate Professor in Ophthalmology.

A full-time member of the Mass. Eye and Ear Retina Service, Dr. Husain also serves as the Director of Mass. Eye and Ear Retina Consultants and as the Director of the Medical Retina Fellowship Program. As an Investigator in the Angiogenesis Laboratory, she primarily conducts translational research pertaining to diseases of the retina, with an emphasis on novel biomarkers for age-related macular degeneration.

John B. Miller, MD
Mass. Eye and Ear, Harvard Medical School, Boston, MA, USA

John B. Miller, MD, is the Director of Retinal Imaging at Massachusetts Eye and Ear and the Associate Director of the Vitreoretinal Fellowship at Harvard Medical School and Mass. Eye and Ear. He graduated from Massachusetts Institute of Technology prior to earning his medical degree at the University of Michigan Medical School. Dr. Miller then completed his ophthalmology residency training at Harvard Medical School and a vitreoretinal fellowship at Mass. Eye and Ear, before joining the Retina Service faculty at Mass. Eye and Ear in 2015. During his time at Mass. Eye and Ear, Dr. Miller has built a busy surgical practice at both the main campus and Longwood locations.

As the Director of Retinal Imaging, Dr. Miller has spearheaded great growth in retinal imaging at Mass. Eye and Ear both in clinical operations and research platforms. He brought the first Swept Source OCT to MEE, completing several projects in macular degeneration, diabetic retinopathy, and choroidal lesions. Currently, Dr. Miller is seeking new correlations in imaging biomarkers with functional measures of retinal disease.
David M. Brown, MD
Vitreoretinal Consultants, Houston, Texas, USA

David M. Brown, MD, is Clinical Professor of Ophthalmology, Cullen Eye Institute, Baylor College of Medicine and vice-chair for research at the Blanton Eye Institute, Houston Methodist Hospital. He is the Director of Clinical Research at the Greater Houston Retina Research Center and in private practice at Retina Consultants of Houston. Dr. Brown graduated from Baylor College of Medicine with highest honors and completed ophthalmology and retina training at the University of Iowa where he was a Thomas Heed Fellow, a Hermann Knapp Fellow, and was awarded the Ron Michels Fellowship award presented to the top retinal surgery fellow in the US.

Dr. Brown’s research and clinical interests are focused on macular surgery, AMD, gene therapy, retinal vascular disease, and diabetic retinopathy. Dr. Brown is an elected member of the Macula Society and the Retina Society and he directs one of the largest clinical trial centers for retinal disease in the US. Dr. Brown's honors include the American Academy of Ophthalmology Honor Award in 2000, the AAO Senior Honor Award in 2014, and continuous election as one of the “Best Doctors in America” 2007 -2017. He has published and written over 400 national meeting presentations, abstracts, and scientific papers including many of the primary papers establishing the use of anti-VEGF agents for AMD, retinal vein occlusions, and diabetic retinopathy.

Karl Csaky, MD, PhD
Retina Foundation of the Southwest, Dallas, TX, USA

Karl Csaky, MD, PhD is a retina specialist and scientist. In addition, he diagnoses and treats medical retina diseases such as age-related macular degeneration and diabetic retinopathy. Dr. Csaky conducts both laboratory and clinical research on age-related macular degeneration and has directed research on new therapies for age-related macular degeneration.

His laboratory is studying the pathogenesis of all forms of age-related macular degeneration, investigating the use of sustained drug delivery as a therapeutic modality. Dr. Csaky is a member of the American Academy of Ophthalmology, the Macula Society, the Retina Society and the Association for Research in Vision and Ophthalmology. He is fellowship trained in retina diseases and is board certified in ophthalmology.
Christopher A. Girkin, MD, MSPH, FACS
EyeSight Foundation of Alabama Endowed Chair Professor and Chairman, Department of Ophthalmology, School of Medicine
University of Alabama at Birmingham, AL, USA

Christopher A. Girkin, MD, MSPH, FACS, is the chairman of the University of Alabama at Birmingham (UAB) Department of Ophthalmology. He completed a fellowship in neuro-ophthalmology at the Wilmer Eye Institute at Johns Hopkins and was a Heed Glaucoma Fellow at the Hamilton Glaucoma Center at the University of California, San Diego. Dr. Girkin has authored or coauthored over 150 journal articles with research focusing on the mechanisms underlying the greater predilection to develop optic nerve injury in individuals of African ancestry. Related hypothesis are explored through patient-oriented research, including morphometric and biomechanical studies of the lamina cribrosa and posterior sclera (utilizing post-mortem human donor tissues (NEI-funded Digital Optic Nerve Episcopic Reconstruction; DONOR library, MPI), imaging of the lamina cribrosa in the NEI-sponsored African Descent and Glaucoma Evaluation Study (ADAGES, MPI), and imaging-based health services research to deliver care to underserved populations in the CDC-sponsored Eye Care Quality and Accessibility Improvement in the Community (EQUALITY, PI) study.

His laboratory has received continuous funding from the National Eye Institute for 15 years, in addition to leading funded projects sponsored by the Centers for Disease Control, the Glaucoma Research Foundation, the American Health Assistance Foundation, Research to Prevent Blindness, the EyeSight Foundation of Alabama and several foundation and industry grants that have brought over $15 million in extramural funding to UAB. He has been awarded the American Glaucoma Society Clinician-Scientist Award, the Research to Prevent Blindness Clinician-Scientist Award, EyeSight Foundation Eminent Scholar Award, the Ronald Lowe Medal, the AAO Senior Achievement Award, the “Best Doctors in America” award yearly since 2003 and is a fellow of ARVO and the American College of Surgeons. He has delivered over 270 lectures to practitioners and researchers throughout the world.
Frank G. Holz, MD, FEBO
Department of Ophthalmology, University of Bonn, Germany

Frank G. Holz, MD, FEBO, is Professor and Chairman of the Department of Ophthalmology at the University of Bonn, Germany. His major clinical interest is medical and surgical retina. His main research interests include the pathogenesis, biomarkers and new therapies for macular and retinal diseases including age-related macular degeneration. He has a keen interest in innovative retinal imaging technologies and image analysis strategies. He was a scholar of the German National Academic Foundation (Studienstiftung des deutschen Volkes), trained at the University of Heidelberg, Germany and the University of Chicago/Pritzker School of Medicine, and passed a fellowship at Moorfields Eye Hospital, London, with Prof. Alan C. Bird. Professor Holz has been a cofounder of the Priority Program AMD of the German Research Council (DFG) and founded the GRADE Reading Center Bonn to perform digital image analysis in clinical natural history and interventional trials with a focus on dry AMD. He is a Board Member of the German Ophthalmological Society (DOG), EURETINA, German Retina Society; Member of the Club Jules Gonin, the European Academy of Ophthalmology (EAO), the Macula Society, the Gass Club; Editor-in-Chief of Der Ophthalmologe; and serves a reviewer for many peer reviewed journals.

He has received numerous awards including the Pro Retina Macular Degeneration Research Award, the Leonhard-Klein Award for Ocular Surgery, the Alcon Research Institute (ARI) Award, and the Senior Achievement Award of the AAO. He published more than 400 articles in peer-reviewed journals and is editor of several books on retinal diseases.

Donald Hood, PhD
Departments of Psychology and Ophthalmology, Columbia University, New York, NY, USA

Donald Hood, PhD, the James F. Bender Professor of Psychology and Professor of Ophthalmic Science (in Ophthalmology), has been a member of the Columbia faculty since 1969. He holds M.Sc. and Ph.D. (1970) degrees from Brown University and honorary degrees from Smith College (2000) and Brown University (2017). He is an elected Fellow of the American Academy of Arts and Sciences and a recipient of an Alcon Research Institute Award (2014). He currently serves on the editorial boards of Documenta Ophthalmologica (since 2004), Translational Vision Science & Technology (since 2011) and IOVS (since 1992). He will be Editor-in-Chief of IOVS as of January 2018. While some of his over 300 publications deal with issues of the basic neuroscience of vision, most of his work over the last 30 years has concerned research on diseases of the retina and optic nerve. He has had continuous grant support from NIH/NEI for over 40 years.
Alex Huang, MD, PhD
Doheny Eye Center of Pasadena, USA

Alex Huang, MD, PhD, graduated from Pomona College and completed his MD/PhD at The Johns Hopkins University School of Medicine with Lasker Award-winning Dr. Solomon Snyder in the Solomon H. Snyder Department of Neuroscience. After completing his residency at then USC/Doheny Eye Institute, Dr. Huang left USC to complete his glaucoma fellowship with Dr. Robert N. Weinreb at the prestigious Shiley Eye Institute. Joining the USC faculty as a clinician-scientist, Dr. Huang left USC for the second time and became one of the inaugural faculty members of the Doheny Eye Institute/Stein Eye Institute/UCLA affiliation.

Dr. Huang is a National Institutes of Health/National Eye Institute supported clinician-scientist on a K08 award. Clinically, Dr. Huang is recognized as a thought leader in new angle-based minimally invasive glaucoma surgeries (MIGS) that he offers to his patients. He has directed his clinical acumen in MIGS into a research program dedicated to developing a combined Structure/Function understanding of aqueous humor outflow using OCT and aqueous angiography. In addition to his NIH support, Dr. Huang also receives research support from American Glaucoma Society, Fight for Sight, and Research to Prevent Blindness. Most recently, Dr. Huang was the Heidelberg Xtreme Research Award winner (2016) and was named the #1 Rising Star by the Ophthalmologist magazine.

Glenn Jaffe, MD
Duke Center for Macular Diseases, Durham, NC, USA

Glenn Jaffe, MD, is the Robert Machemer Professor of Ophthalmology and a member of the vitreoretinal faculty at Duke University Eye Center. He is chief of the Vitreoretinal Division, and founded and directs the Duke Reading Center. Dr. Jaffe received his medical degree and his ophthalmology residency training at the University of California, San Francisco. He completed a two-year combined clinical and research vitreoretinal fellowship at the Medical College of Wisconsin. He joined the faculty at Duke University in 1989.

He has published over 250 articles in peer-reviewed journals and has an active clinical and basic science research program. Dr. Jaffe treats patients with a variety of medical and surgical vitreoretinal and uveitis diseases. His clinical research interests include the use of optical coherence tomography in clinical retinal treatment trials novel medical and surgical therapies of uveitis and other posterior segment disorders. He has been a pioneer in the development of sustained drug delivery systems to treat ocular disease. He has participated in numerous clinical trials of new therapies for uveitis and vitreoretinal diseases. He directs a basic research program to investigate the mechanisms responsible for macular degeneration.

Dr. Jaffe serves on the Editorial Board of the journals Retina, Current Opinions in Ophthalmology, and Ocular Surgery News and reviews manuscripts for a variety of clinical and investigative ophthalmology journals.
**Christian Mardin, MD, FEBO**  
Department of Ophthalmology, University Erlangen-Nürnberg, Germany

Christian Mardin, MD, FEBO, is senior consultant at the department of ophthalmology of the University Erlangen-Nuernberg in Erlangen, Germany.

He graduated at the University of Erlangen (Germany) in 1991 and spent his residency with GOH Naumann at the University of Erlangen until 1996. He wrote his doctorate thesis with J Jonas on the morphometry of the human lamina cribrosa and has since been interested in posterior segment and disc imaging with emphasis on glaucomas. He led several projects funded by DFG (German Research Foundation) on the topic of optic disc imaging. He became associate professor in 2000 and full professor in 2006.

His research, publications and lectures have an emphasis on glaucoma diagnosis and genetics. He has been a member of ARVO since 1990, DOG since 1991 and SIDUO since 1996.

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**Mark Nelson, MD**  
North Carolina Macular Consultants, Winston-Salem, NC, USA

Mark Nelson, MD is a vitreoretinal specialist in Winston-Salem, NC. He has a medical degree from Rutgers Robert Wood Johnson Medical School and a MBA from Wake Forest University. He now focuses his clinical practice on imaging for the diagnosis and treatment of Exudative ARMD and cytokine analysis for the treatment of Diabetic Macular Edema. He has lectured extensively on the pharmaco economics of treating Exudative Maculopathies.
SriniVas R. Sadda, MD
Doheny Eye Institute, University of California, Los Angeles, CA, USA

SriniVas R. Sadda, MD, is the President and Chief Scientific Officer of the Doheny Eye Institute, the Stephen J. Ryan – Arnold and Mabel Beckman Endowed Chair, and Professor of Ophthalmology at the University of California – Los Angeles (UCLA), David Geffen School of Medicine. He received his medical degree from The Johns Hopkins University in Baltimore, Maryland. After an internship at the William Beaumont Hospital in Royal Oak, Michigan, he returned to Johns Hopkins University and the Wilmer Eye Institute in Baltimore for an ophthalmology residency as well as neuro-ophthalmology and medical retina fellowships.

Dr. Sadda’s major research interests include automated retinal image analysis, retinal substructure assessment, advanced retinal imaging technologies, and vision restoration approaches. His research has been consistently funded by the National Institutes of Health (NIH) and multiple private organizations including the Foundation Fighting Blindness, Research to Prevent Blindness, Foundation for Retinal Research, and the Macula Vision Research Foundation. He has organized multiple consensus efforts for the classification of various retinal disorders. Dr. Sadda has served as Principal Investigator for over 30 major clinical trials, and has led several international collaborative research programs. He is the founder and Emeritus Director of the Doheny Image Reading Center, one of the largest centralized reading centers in the world. He has more than 380 publications in peer-reviewed journals and over 300 published abstracts. He authored the first edition of the textbook Emerging Technologies in Retinal Disease, as well as 14 other book chapters. As an invited lecturer, he has given more than 350 presentations around the country and the world, including multiple named lectures. Dr. Sadda also serves as an editorial board member of Ophthalmic Surgery, Lasers & Imaging, Retina, Graefe’s Archive for Clinical and Experimental Ophthalmology, Ophthalmology Retina, and Ophthalmology. He is also an editor of the 5th edition of the Ryan’s Retina textbook. He regularly serves the NIH Center for Scientific Review on study section.

Among Dr. Sadda’s awards and honors are a Research to Prevent Blindness Physician-Scientist Award, a Senior Honor Award from the American Society of Retina Specialists, a Senior Achievement Award and Secretariat Award from the American Academy of Ophthalmology, John H. Zumerge Research and Innovation Award, the Macula Society Young Investigator Award, Asia-Pacific Academy of Ophthalmology (APAO) Achievement Award, The Macula Society Paul Henkind Lecture and Award, and American Society of Retina Specialists Young Investigator Award. He has also received the Silver Fellow designation from the Association for Research in Vision and Ophthalmology. He has been named to the Best Doctors of America list for several consecutive years.
Giovanni Staurenghi, MD  
Sacco Hospital, University of Milano, Italy

**Giovanni Staurenghi, MD,** presently Professor of Ophthalmology, is Chairman of the University Eye Clinic at Department of Biomedical and Clinical Science “Luigi Sacco” University of Milan, Italy.

He got his degree at the University of Pavia (Italy) in 1986 and his residency at the University of Milan (Italy) in 1990. He was research fellow at the Schepens Eye Research Institute from 1991 to 1992 and Visiting Scientist at the same Institute from 1992 to 1993. He became associate professor in 1999 and full professor in 2007.

His research, publications and lectures have an important bearing on retinal degeneration; in particular his work is oriented on different types of imaging and treatment. He has been a member of ARVO since 1988, Macula Society since 2004, Ophthalmic Photographer Society since 2006 and American Accademy of Ophthalmology since 2007. He is also a Silver Medal Fellow of ARVO and a member of the Gass Club.

He serves as Editorial Board Member for IOVS, Retina and American Journal of Retinal Cases and as Reviewer.

Robert N. Weinreb, MD  
Department of Ophthalmology, Hamilton Glaucoma Center and Shiley Eye Institute University of California, San Diego La Jolla, CA, UC San Diego Health - La Jolla, Shiley Eye Institute, CA, USA

**Robert N. Weinreb, MD,** is Distinguished Professor and Chair, Ophthalmology, at the University of California, San Diego. He also is the Director of both the Shiley Eye Institute and the Hamilton Glaucoma Center, holder of the Morris Gleich Chair in Glaucoma, and Distinguished Professor, Bioengineering. He received his medical degree from Harvard Medical School and degrees in electrical engineering and mathematics at the Massachusetts Institute of Technology.

Dr. Weinreb is a physician scientist. His glaucoma research ranges from the front to the back of the eye and from the clinic to the laboratory. His innovative work has significantly impacted our understanding of the biology of glaucoma, as well as its diagnosis and management. He has had continuous NIH/NEI funding since residency and his h-impact factor is 109.

The recipient of numerous prestigious awards and prizes, Dr. Weinreb has trained more than 150 post-doctoral fellows, many of whom hold distinguished positions throughout the world in academia (12 chairs and 55 professors) and industry. He is a past President of the Association for Research in Vision and Ophthalmology (ARVO), American Glaucoma Society (AGS), World Glaucoma Association (WGA), American Glaucoma Society Foundation (AGSF), and the Pan American Glaucoma Society (PAGS).
Christine Curcio, PhD
Professor of Ophthalmology, University of Alabama at Birmingham
School of Medicine, Birmingham AL, USA

Christine Curcio, PhD, focused her research on chorioretinal aging and
age-related macular degeneration (AMD) through collaborative
multidisciplinary studies of human donor eyes. Trained in neuroanatomy,
ultrastructure, and morphometry at Universities of Rochester and
Washington, her 1990 studies of human photoreceptor and ganglion cell
topography provided a histologic basis for in vivo single-cell retinal imaging.

Contributions include documenting that rods die before cones in aging and
AMD; characterizing and contextualizing lipoproteins as the largest
ultrastructural component of soft drusen; naming and initial description of
subretinal drusenoid deposit; comprehensive description of retinal pigment
epithelial morphology; the Project MACULA online resource for AMD
pathology. She received the Roger H. Johnson Prize (2002), Prix Soubrane
de la Recherche en Ophtalmologie (2011), and the Ludwig von Sallmann
Prize (2014). Funded by the National Eye Institute since 1985, current
research focuses on the cell and tissue basis of optical coherence
tomography and fundus autofluorescence, capitalizing on a national
treasure, the Alabama Eye Bank. Dr. Curcio serves on the editorial board of
Investigative Ophthalmology and Visual Science and the Diseases and
Pathophysiology of Visual System NIH study section.

François Delori, PhD
Schepens/MEEI, Department of Ophthalmology, Harvard Medical
School, Boston, MA, USA

François Delori, PhD, obtained his PhD in physics from Imperial College in
London in 1972 and has worked at the Schepens Eye Research Institute
since 1980. He is now a Senior Scientist at the Institute and Professor in
Ophthalmology at Harvard Medical School. His interests include light
damage to the retina, and the role of macular pigment and of RPE lipofuscin
in age-related retinal degeneration and other retinal degenerations.

Delori’s field of expertise is the “noninvasive” testing of the retina. Using
retinal reflectometry and fluorospectrometry, he was able to obtain
quantitative information about many important biological parameters
(oxygen levels in retinal vessels, blood flow, diffusion of nutrients, quantity
of pigments such as macular pigment, melanin, and lipofuscin). Since 1995
his focus has been on the origin and characteristics of the autofluorescence
of the retinal pigment epithelium. In collaboration with Columbia University
(NY), he has developed a method to quantify this autofluorescence, which
allowed the completion of comprehensive studies in healthy subjects, and in
patients with Stargardt disease, Best vitelliform macular dystrophy, and
other retinal degenerations.
Massimo Fazio, PhD
The University of Alabama at Birmingham, AL, USA

Massimo Fazio, PhD, has, as a mechanical engineer, dedicated his career to developing customized methods and non-contact optical techniques to measure deformations in loaded materials to gain a deeper understanding of the biomechanical properties of ocular tissues. His work is currently focused on investigating how intraocular pressure (IOP) drives structural changes in the eye in relationship to age, race, and ocular diseases like glaucoma.

Through his multidisciplinary background in machine construction, experimental mechanics and the biomechanical characterization of soft tissues, Dr. Fazio is able to develop novel imaging machines and techniques. Originally from Italy, Dr. Fazio earned his master's of science in engineering as well as his doctorate in mechanical engineering from the University of Calabria in Cosenza, Italy. He then completed further postdoctoral training in ocular biomechanics at the Devers Eye Institute in Portland, Oregon. Dr. Fazio was recruited to UAB in 2012. Dr. Fazio is a member of numerous professional organizations including the American Society of Mechanical Engineers, Association for Research in Vision and Ophthalmology, Optical Society of America, and International Society for Eye Research.

Ari Green, MD
UCSF MS Center, San Francisco, CA, USA

Ari Green, MD, is a neurologist and neuro-ophthalmologist. He is medical director of the UCSF Multiple Sclerosis Center, where he treats adults and children with MS and other inflammatory diseases of the central nervous system. Dr. Green specializes in treating vision problems that result from these conditions, including optic neuritis and double vision. He is also director of the UCSF Neuodiagnostic Center. Dr. Green's research focuses on developing tests that help bring reparative treatments to patients with MS and halt neurodegeneration in patients with diseases that cause neurological deterioration. His work aims to advance treatments that would enable recovery after injury to the myelin sheath - the protective layer around nerve fibers in the brain and spinal cord.

Dr. Green has led a team dedicated to bringing advanced imaging and electrophysiological measures of the visual system and brain to the clinic. His team pioneered early-stage testing of promising new treatments for optic neuritis, MS and other diseases of the central nervous system. In his laboratory, Dr. Green supervises postdoctoral fellows and students on projects related to this work. Dr. Green earned his medical degree at Duke University School of Medicine, where he was a Howard Hughes Medical Institute Predoctoral Fellow for two years. He then completed his residency in neurology at UCSF, where he spent time as chief resident, followed by UCSF fellowships in neuroimmunology and neuro-ophthalmology. In 2005 the American Academy of Neurology and National Multiple Sclerosis Society named Dr. Green their first clinical research fellow. He is an assistant professor at UCSF and holds the titles of Debbie and Andy Rachleff Distinguished Professor of Neurology and Harry Weaver Neuroscience Scholar. He is a member of the American Academy of Neurology, Association for Research in Vision and Ophthalmology, North American Neuro-Ophthalmology Society and Association for Clinical and Translational Science. He is associate editor of JAMA Neurology.
Kouroso Souri-Mahdavi, MD, MSc
Doris Stein Eye Research Center, Los Angeles, CA, USA

Kouroso Souri-Mahdavi’s, MD, MSc, research focuses on functional and structural measurements in glaucoma and the study of surgical outcomes. As the Director of the Glaucoma Advanced Imaging Laboratory at Stein, he leads a team of investigators studying the utility of OCT imaging for detection of early disease and especially identifying disease progression.

Dr. Nouri-Mahdavi has been the recipient of many awards including the American Academy of Ophthalmology’s Achievement Award, American Glaucoma Society MAPS Grant Award, the American Glaucoma Society Early and Mid-Career Clinician Scientist Awards, the Gerald Oppenheimer Family Foundation Center for Prevention of Eye Disease Award, a CTSI seed grant for study of gait in glaucoma patients, and an ongoing study supported by an NIH K23 award on detection of glaucoma progression with macular SD-OCT imaging.

Dr. Nouri-Mahdavi is a clinician-scientist who continues to teach and publish extensively. He frequently lectures at national and international meetings. He has published more than 75 articles in the field of glaucoma. He is currently a member of the American Glaucoma Society’s International Education Committee, and American Academy of Ophthalmology’s Ophthalmic Technology Assessment Committee, and serves on the Editorial Boards of Journal of Glaucoma and Journal of Ophthalmic and Vision Research.

Dr. Nouri-Mahdavi’s clinical practice is focused mainly on management of glaucoma and complicated cataracts in adult patients. His specific areas of interest are management of complex cases of (secondary) glaucoma, geriatric glaucoma, and minimally invasive glaucoma surgeries (MIGS) for treatment of early to moderate disease.

Osamah Saeedi, MD
University of Maryland Medical Center, Baltimore, MD, USA

Osamah Saeedi, MD is an Associate Professor of Ophthalmology at the University of Maryland School of Medicine in Baltimore, MD. Dr. Saeedi completed medical school and ophthalmology residency at the University of Texas – Southwestern Medical Center, and glaucoma fellowship at the Wilmer Eye Institute, Johns Hopkins University.

Dr. Saeedi is the recipient of an NIH Career Development Award (K23) and has grant funding from numerous other organizations including the American Glaucoma Society. His research focuses on finding novel imaging biomarkers for glaucoma, specifically looking at new techniques for assessing ocular blood flow.
Quantitative Fundus Autofluorescence

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**Purpose:** The autofluorescence (AF) of the retina originates from lipofuscin, a pigment which accumulates throughout life in the Retinal Pigment Epithelium as a byproduct of the visual cycle and is a complex mixture of bisretinoids (including A2E) and their oxidized forms. Mutations in photoreceptor genes also can have a direct impact on the production of RPE lipofuscin.

**Methods:** AF images (30°, 486 nm excitation) were acquired with a confocal scanning laser ophthalmoscope (Spectralis, Heidelberg Engineering) equipped with an internal fluorescent reference to account for variable laser power and detector sensitivity. The grey levels (GLs) of each image were calibrated to the reference taking into account zero GL, magnification, and normative optical media density, to yield AF levels for all point of the AF images.

**Results:** Spectral and quantitative data demonstrates that lipofuscin increases significantly with age in most conditions and has a well-defined spatial distribution throughout the fundus. Additional fluorescence emanates from Bruch’s membrane deposits at old age and in AMD. Mutations in the ABCA4 genes in Stargardt disease results in significant higher than normal levels of lipofuscin.

**Conclusions:** This technique may aid in achieving a better understanding of the role of lipofuscin in disease pathogenesis, and could contribute to the assessment of drug and gene therapies.
Erythrocyte Mediated Angiography in Human Subjects

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Purpose/Relevance: Ocular blood flow may play a significant role in the development and progression of diseases such as macular degeneration, diabetic retinopathy, and glaucoma. Prior work assessing the role of blood flow in ocular pathology has focused on bulk blood flow or blood velocity, which has certain limitations in determining the metabolic activity and oxygenation of a given capillary bed. Erythrocyte Mediated Angiography (EMA) is a novel technique that permits direct visualization of ICG-labelled ghost erythrocytes in vivo, to study ocular blood flow. This permits the accurate determination of erythrocyte velocity and erythrocyte pausing. Prior work in Non-Human Primates (NHP) shows that NHPs with experimentally induced glaucoma show impaired vasomotion which manifests as proportionally fewer paused erythrocytes. This was also true in NHPs with induced retinal vein occlusions. We present preliminary data on the safety and efficacy of this technique in a human study for assessment of erythrocyte pausing and erythrocyte velocity in glaucoma patients and controls.

Methods: Glaucoma patients and healthy controls were recruited. EMA was performed using a Heidelberg HRA 2 Scanning Laser Ophthalmoscope (Heidelberg Engineering, Heidelberg Germany). Twelve to fifteen second angiograms of the optic disc and macula of each individual were then graded to assess erythrocyte pausing and erythrocyte velocity.

Results: Thirty-five eyes of nineteen patients underwent Erythrocyte Mediated Angiography, 10 with diagnoses of glaucoma or glaucoma suspect and 9 normal controls. This was followed by conventional liquid ICG Angiography. One patient had a syncopal event associated with the conventional ICG angiography, but otherwise tolerated EMA without complication. There was evidence of erythrocyte pausing in the retina of all eyes studied, and in the optic nerve in 10 patients. Erythrocyte velocity was determined in smaller veins and arteries.

Conclusion: Erythrocyte Mediated ICG Angiography is a novel technique that can be used to assess erythrocyte dynamics in the retina and optic nerve head. EMA may prove to be a more sensitive marker of ocular blood flow than prior methodologies, and could potentially become a biomarker for development and progression of ocular disease.
Microarchitecture and Timeline of Atrophy in AMD via Histology and Eye-Trackd SD-OCT

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Purpose: Pairing a new morphologic catalog of retinal pigment epithelium (RPE) and basal laminar deposit (BLamD) with longitudinal eye-tracked SDOCT, we sought a timeline of RPE fate over drusen in age-related macular degeneration (AMD).

Methods: High-resolution histology from 53 late AMD eyes (13 geographic atrophy, GA, and 40 neovascular AMD) and one eye from a donor with late AMD and in vivo SDOCT was used to generate 15-point system for morphology of epithelial RPE and RPE-derived cells in the retina and the sub-RPE-basal laminar (BL) space. Two main pathways of RPE fate were hypothesized (anterior migration, apoptosis in situ). Volumes of drusenoid RPE detachments (DPED) in 49 eyes of 33 patients followed 4.9 ± 2.5 years were measured. A hyperreflective line across GA was traced back to drusen in 8 eyes of 7 patients.

Results: Fully pigmented and nucleated RPE were correlated to intraretinal hyperreflective foci. DPED grew slowly over months then collapsed. Intraretinal hyperreflective foci appeared vertically above and several months after disturbances of the RPE-BL band. This band disintegrated, then the DPED collapsed. A reflective line of persistent BLamD (“plateau”) sometimes remained across the atrophic zone.

Conclusions: RPE activation and migration comprise an important precursor to atrophy that is observable at the cellular level in vivo via validated SDOCT. Collapse of large drusen and drusenoid PED appears to occur when RPE death and migration prevent continued production of drusen components. Data implicate excessive diffusion distance from choriocapillaris in RPE death as well as support a potential benefit in targeting drusen in GA.
Positional Advanced Ophthalmic Imaging

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Purpose: Humans take multiple body positions throughout the day and during sleep (seated, supine, prone, lateral, inclined etc…). However, all ophthalmic testing is done in the seated position. Different body positions influence different internal homeostatic mechanisms and may have impact on the eye. Different body positions can influence fluid shifts which is a model for a potential mechanism for visual impairment in microgravity and space.

Methods: The Heidelberg Spectralis FLEX module was originally developed for supine imaging of aqueous humor outflow (aqueous angiography) discussed later in this program. The FLEX is a surgical boom arm that allows for imaging (optical coherence tomography [OCT] or angiography) in nearly any body position. Posterior segment and anterior segment OCT was performed in various positions such as seated, supine, and 15-degrees head-down tilt. Countermeasures for visual impairment in space was tested using the FLEX module.

Results: Horizontal or head-down tilt positions increased intraocular pressure (IOP). Body position altered anterior segment lens position. Various body positions, mimicking cephalad fluid shifts, served as a model for visual impairment in space demonstrating increased IOP and subfoveal choroidal thickness. Countermeasures successfully reversed these alterations.

Conclusion: Humans spend a significant proportion of their time in non-seated positions (outside of the body position used for routine ophthalmic testing), and the contribution of body position and fluid shifts to disease is an emerging area. Spectralis FLEX-based imaging may be critical in understanding these processes in addition to evaluating visual mysteries such as vision loss in space.
Multimodal Imaging of Non-Neovascular Exudative AMD

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**Purpose:** To describe the characteristics and natural history of patients with quiescent exudation with persistent subretinal fluid associated with pigment epithelial detachment (PED).

**Methods:** Multimodal imaging including fluorescein angiography (FA), indocyanine green angiography (ICGA), optical coherence tomography (OCT), swept source OCT, and OCT angiography were obtained.

**Results:** We present a series of cases typically classified as exudative AMD, who have persistent but stable subretinal fluid (SRF) with good visual acuity. Our series of patients all had visual acuity better than 20/25. OCT typically shows a moderately reflective irregular PED with overlying SRF. Traditional FA does not show definite leakage, but presents as an ill-defined hyperfluorescent late-phase lesion. ICGA usually shows no definitive neovascular network, but OCT-A clearly demonstrates a vascular network within the PED. The majority of our cases did not receive anti-VEGF injections and remained without progression over several years (9 months to 11 years). Two eyes received continuous injections but showed no change in disease course with persistent SRF.

**Conclusion:** OCT-A has allows us to identify choroidal neovascularization (CNV) that we could not visualize with traditional methods. However, this subset of patients suggests that there may be a broad spectrum of disease activity, and that some cases may represent a more quiescent and stable CNV. SRF may not be a sign of active neovascularization, and other features such as increased intraretinal fluid or new onset retinal hemorrhage may be the best guide to initiate or resume anti-VEGF in this subset of patients.
Multimodal Imaging in Dry Age-Related Macular Degeneration (AMD) Using Quantitative Fundus Autofluorescence (qAF)

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Purpose: One of the earliest detectable disease markers in AMD is an abnormal pattern of in vivo autofluorescence (AF). These imaging changes are attributed to differences in the amount or distribution of bisretinoid fluorophores in the retinal pigment epithelium (RPE) lipofuscin. By examining these differences and tracking any changes in a quantitative manner, via qAF imaging, we may shed light on the role of lipofuscin and its fluorophores in the progression of various AMD phenotypes. This study aims to re-examine the theory of lipofuscin toxicity.

Methods: We obtained serial infrared imaging, spectral-domain optical coherence tomography (OCT) and qAF levels on pseudophakic subjects older than 60 years old of different dry AMD phenotypes using the Spectralis HRA + OCT as well as different imaging modalities such as fundus photography, fluorescein/indocyanine green angiography and/or OCT angiography. A comprehensive medical questionnaire and a consent form were included for each patient.

Results: AMD eyes had a lower mean pericentral qAF (qAF-8) level than normal age equivalent eyes. Results varied according to AMD phenotype (soft drusen, soft drusen with intraretinal pigment, reticular macular disease/reticular pseudodrusen/subretinal drusenoid deposits and cuticular drusen). Sentinel examples will be presented. Greater qAF in geographic atrophy lobules was associated with focal RPE preservation.

Conclusions: qAF of dry AMD decreases from normal aging to early up to late AMD, suggesting that loss of lipofuscin fluorophores, the source of AF, signifies AMD progression. qAF could serve as a robust clinical biomarker of RPE health, improving understanding of AMD and be a useful clinical trial outcome.
Purpose: Fundus autofluorescence (FAF) imaging allows for topographic mapping of naturally or pathological occurring fluorophores at the posterior pole. It is particularly helpful for the assessment of the retinal pigment epithelium/photoreceptor complex and macular pigment distribution.

Methods: The Spectralis instrument allows for both blue and green fundus autofluorescence as well as near-infrared autofluorescence imaging. Quantitative autofluorescence (qAF) imaging now allows for quantitation of signals derived from fundus autofluorescence imaging. By using an inserted a reference fluorophore into the optical pathway. Besides the generation of reference values in normal probands, patients with a wide variety of retinal diseases were examined.

Results: Fundus autofluorescence imaging allows for refined phenotyping and detection of novel biomarkers. Such markers have been shown to be useful for early detection of diseases as well as for progression prediction. GAF-based measurements were on average 0.062 mm (95% confidence interval [CI] 0.04-0.08 mm) larger than BAF+NIR-based measurements and 0.077 mm (95% CI 0.06 - 0.10 mm) larger than BAF-based measurements. Interreader agreement was highest for GAF-based analysis ([CR, ICC] 0.196 mm, 0.995) followed by BAF+NIR (0.232 mm, 0.992) and BAF alone (0.263 mm, 0.991). The same was noted for the lesion perimeter and circularity. Post hoc review revealed that interreader differences were associated with media opacification interfering with lesion boundary demarcation to a larger extent in BAF than in GAF. Other advantages of longer-wavelength excitation (green) light include less absorption by the crystalline lens especially in patients with cataracts as well as better patient comfort. The use of qAF is helpful in the differential diagnoses particularly of monogenetic retinal degenerations but also in new insights in pathophysiological factors at the level of the RPE. has been shown to be useful for various assessments, e.g. to distinguish ABCA4-related macular dystrophies from other forms of macular dystrophies.

Conclusions: Fundus autofluorescence imaging adds to a better understanding of macular and retinal diseases. It represents a helpful tool both for research application and for clinical routine. Blue, green and near-infrared FAF available in the Spectralis instrument may serve different purposes in clinical application. cSLO-based GAF and combined BAF+NIR imaging with semiautomated lesion delineation allow for an accurate and reproducible quantification of GA. The slightly better interreader agreement using cSLO GAF suggests that its use may be preferable in clinical trials examining the change in lesion size as a clinical endpoint. Quantative AF imaging further enhances our understanding of disease processes and will be useful for monitoring therapeutic effects of therapeutic interventions as well as for natural history studies in monogenic and complex macular retinal diseases.
Swept Source OCT of Choroidal Lesions

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Purpose: To image choroidal lesions with swept-source optical coherence tomography (SS-OCT) and to identify the morphologic characteristics associated with optimal visualization.

Methods: Patients with choroidal melanocytic lesions < 3 mm in thickness on B-scan ultrasonography were recruited. All participants underwent color fundus photography (CFP), B-scan ultrasonography, and SS-OCT. All images were evaluated by two independent graders. CFP were used to assess the degree of pigmentation of lesions. On SS-OCT we evaluated various qualitative (e.g. lesion outline, detection of scleral-choroidal interface, and quality of the image) and quantitative parameters (measurement of maximum lesion thickness and the largest basal diameter). Probability of optimal image quality was examined using ordered logistic regression models. The main outcome measure was quality of the choroidal lesion images on SS-OCT, defined as: optimal - all margins of the lesion well visible; suboptimal - at least one margin not properly imaged; or poor - more than one margin not properly imaged.

Results: We included 85 choroidal lesions of 82 patients. The mean age of the patients was 65.8 ± 11.8 years. Forty-eight lesions (59%) were from female patients. There were 24 choroidal lesions (29%) for which image quality was classified as optimal, 31 lesions (37%) as suboptimal, and 30 lesions (36%) as poor. The factors associated with optimal image quality were distance closer to the fovea (OR 0.76, \( P < 0.001 \)), posterior pole location (OR 3.87, \( P = 0.05 \)), lower ultrasound thickness (OR 0.44, \( P = 0.04 \)), lighter lesion pigmentation (OR 0.12, \( P = 0.003 \)) and smaller lesion diameter (OR 0.73, \( p<0.001 \)). In the multi-variable analysis, closer distance to the fovea (OR 0.81, \( P = 0.005 \)), lighter lesion pigmentation (OR 0.11, \( P = 0.01 \)) and smaller lesion diameter (OR 0.76, \( p=0.006 \)) remained statistically significant.

Conclusion: SS-OCT is useful in imaging most choroidal melanocytic lesions. Image quality is best when the choroidal lesion is closer to the fovea, has a smaller diameter and a lighter choroidal pigmentation.
Choroidal and Sub-Retinal Pigment Epithelium Caverns: Multimodal Imaging Characteristics and Relation to Friedman Lipid Globules

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Purpose: Extracellular lipid globules were first shown histologically in choroidal stroma of healthy eyes by Friedman[1] and also in geographic atrophy (GA) and neovascular (nv) tissue in age related macular degeneration (AMD)[2]. Querques described hyporeflective choroidal caverns in GA by optical coherence tomography (OCT)[3] and OCT angiography (OCT-A)[4]. We observed similar OCT signatures in the subretinal pigment epithelium (sub-RPE) space in nvAMD, and in the choroid of several retinal diseases. We investigated multimodal imaging features of choroidal and sub-RPE caverns, their relation to histology, and hypothesized on their nature.

Methods: Forty-one eyes of 28 subjects underwent multimodal imaging, including color fundus, near-infrared reflectance (NIR), spectral-domain (SD) or swept source (SS) structural OCT and OCT-A (cross-sectional, en face).

Results: Caverns were seen in eyes with GA(16), nvAMD(8), Stargardt disease(4), cone dystrophy(2), pachychoroid spectrum(6), choroidal hemangioma(1), and healthy eyes(4). En face OCT showed sharply delimited hyporeflective areas as large as choroidal vessels, frequently grouped around or following choroid vessels or in the nv tissue. Cross-sectional OCT showed a characteristic posterior hypertransmission. In the presence of RPE atrophy, SD and SS-OCT were both useful. If RPE was intact, SS-OCT was superior in detecting choroidal caverns. OCT-A showed absence of flow signal within caverns. Caverns were hyperreflective on NIR.

Conclusions: We describe the presence of hyporeflective choroidal and sub-RPE caverns in a wide spectrum of retinal diseases and healthy subjects. Based on the optical similarity to intraretinal silicon oil droplets (hyporeflective with hypertransmission), we speculate that caverns are lipid-rich. Friedman lipid globules, with similar sizes and tissue locations in AMD and healthy subjects, are candidates for histologic correlates of caverns. Their role in chorioretinal physiology, perhaps as a lipid depot, is approachable through clinical imaging.

Subclinical CNV – What is the Threshold for Treatment with Anti-VEGF Monotherapy?

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**Purpose:** The early diagnosis of CNV in asymptomatic patients with Type 1 Occult Exudative ARMD by OCT Angiography requires a new set of treatment parameters for anti-VEGF monotherapy.

**Methods:** Retrospective, non-randomized study of 474 patients with treatment-naive and treated Type 1 Exudative ARMD who were evaluated by OCTA (Heidelberg Beta Version). Exclusion criteria involved concurrent vasculopathies, optic neuropathies, and/or the presence of previous vitrectomy. Preoperative VA, OCT, IOP, IVFA/ICG Videoangiography and OCTA were performed. Correlation to VA, degrees of subRPE, subretinal and intraretinal exudation, heme, and changes in OCTA were determined to evaluate new biomarkers for threshold treatment.

**Results:** 84.2% of the 474 patients with Type 1 Exudative ARMD had distinct CNV noted on OCTA. These lesions were less apparent on ICG videoangiography and not appreciated at all on IVFA. 6.4% of these patients were subthreshold for anti-VEGF monotherapy utilizing standard criteria and an additional 6.9% had a pachychoroid presentation with CNV. Of the 15.8% who did not have CNV on OCTA, 15.8% of these patients were threshold for anti-VEGF monotherapy utilizing standard criteria.

**Conclusion:** OCTA provides a higher quality image of CNV compared to ICG Videoangiography. OCTA has created a new subset of patients who have early CNV, mild leakage, and who will most likely benefit from early anti-VEGF monotherapy. Randomized studies will be necessary to determine the natural history of these lesions and to create a new set of parameters for the correct timing of such treatment.
Clinical Evaluation of an Intensively Genotyped Cohort of Macular and Cone/Cone-Rod Dystrophy Patients

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Purpose: Macular and cone/cone-rod dystrophies are genetically and clinically heterogeneous retinal disorders. Although the phenotype of some diseases may be characteristic for a specific genotype, phenotype-genotype correlations have not been established in many cases. A comprehensive molecular diagnosis supports patient counseling and progression prediction. In this retrospective, observational study we clinically and genetically characterized a large cohort of macular and cone/cone-rod dystrophies.

Methods: A two-tier procedure was implemented to identify the molecular cause in 251 consecutive patients in a tertiary German referral center. If the retinal phenotype was highly suggestive for causative mutations in ABCA4, PRHP2 or BEST1, Sanger sequencing (and, in case of ABCA4, MLPA) for these genes was performed. If this initial molecular testing was negative or if the phenotype was not suggestive for retinopathy associated with these genes, targeted next-generation sequencing (NGS) on an Illumina Hiseq1500 system was carried out for 375 genes after enrichment using NimbleGen sequence capture technology. All patients underwent standardized clinical examination and imaging, including spectral domain optical coherence tomography, wide field fundus autofluorescence imaging and fundus photography. Retinal function testing included best corrected visual acuity, electroretinography and visual field testing.

Results: Pathogenic mutations were identified in 188 (75%) out of the 251 patients. ABCA4, PRPH2 and BEST1 were responsible for 38%, 12% and 8% of the resolved cases. Mutations were distributed over 22 genes. Potential novel genotype-phenotype correlations were identified in additional 7 cases. Patients whose causative mutation remained unsolved frequently presented with phenotypes resembling central areolar choroidal dystrophy (CACD), mitochondrial retinal dystrophy, or unspecific adult vitelliform or pattern dystrophy.

Conclusion: Targeted NGS detected a large mutational spectrum in patients with macular and cone/cone-rod dystrophies, indicating the need for unbiased genetic testing for this genetically heterogeneous disease group. The phenotype characteristics shared by patients without detected mutations suggest common genetic causes that might explain subsets of this cohort.
Don’t be Puzzled by Multimodal Imaging

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**Purpose:** Multimodal Imaging (MMI) is the photographic technique employed to evaluate and describe the correlative and additive findings seen in Fluorescein angiography (FA), Indocyanine green angiography (ICGA), optical coherence tomography (OCT), fundus autofluorescence (FAF), blue reflectance (BR) MultiColor (MC) and OCT-Angiography (OCT-A) using the Spectralis HRA-OCT in imaging various ophthalmic pathologies.

**Methods:** During routine clinical work, various imaging modalities were employed according to their proven ability to highlight disease-specific findings, including FA for non-perfusion and leakage, OCT for retinal structural changes, ICGA for choroidal lesions and FAF for choroidal inflammatory diseases. In addition, stereo photography was included when topographic changes were noted. When uncertain as to which modality is to be used, our staff records several image types to be reviewed later.

**Results:** By using more than one imaging modality to view different cases, we were able to both expand our understanding of the changes specific to each entity, as well as better tailor our imaging protocol for documenting future cases – as in supplanting OCT-A for FA in some diabetic retinopathies, employing FAF in all choroidal inflammatory cases, adding BR images in suspected Mac Tel cases and preforming routine stereo FA and ICGA photography.

**Conclusions:** Multimodal Imaging has broadened our appreciation of the various changes present in retinal and choroidal diseases. With experience, we have been able to standardize our imaging protocol and thereby arrive at more accurate and timely diagnoses, as well as offer follow-up images aimed at highlighting change best documented with specific modalities. This ‘detective-like’ approach is best demonstrated by completing a Multimodal Imaging Puzzle, which highlights the imaging modalities used in different cases.
Drusen Volume and Visual Function Measures in Dry AMD

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Purpose: Low luminance deficit (LLD) is often found in AMD and is thought to be a result of cone dysfunction. Decreases in scotopic sensitivities are due to a loss of rod function a consistent finding in AMD. Anatomically the extent of drusen deposition is thought to be a marker of AMD severity. The goals of the present study were 1) to determine if photoreceptor dysfunction is generalized throughout the retina by examining the correlation between LLD and scotopic sensitivities and 2) the relationship of visual function testing to the accumulation of drusen.

Methods: Subjects with early AMD (n=6, age 63.7 ± 4.7), intermediate (n=31, age 73.6 ±9.9), geographic atrophy (n=8, age 74.7 ±7.0), and age-match controls (n=8, age 67.8 ±9.3) were examined. Following 30 minutes of dark adaptation, scotopic sensitivities were measured at 56 locations with a Goldmann spot size 3 within 10° of the fovea (MP-1S, Nidek Technologies) and neutral density filters to adjust the dynamic range to the individual’s mean sensitivity. Points falling on patches of geographic atrophy were eliminated from analysis. Visual acuity was measured with ETDRS chart. Low luminance visual acuity was measured with an occluder with a 2.0 neutral density filter. LLD was measured by subtracting the number of letters in the low luminance conditions from the number of letters in the normal luminance levels. Contrast sensitivity function (CSF) was determined with the Sentio platform (Adaptive Sensory Technology, San Diego, CA), a device that applies Bayesian adaptive algorithms to measure the full CSF across a wide range of spatial frequencies. The full CSF was summarized by the area under the Log CSF (AULCSF) from 1.5 to 18 cyc/deg. Low luminance VA and CSF were obtained following placement of a 2 ND filter over the study eye. Low luminance deficits (LLD) for VA and AULCSF were calculated by subtracting low luminance VA and AULCSF from normal luminance VA and AULCSF, respectively. Drusen volume was determined by automated segmentation of the sub-RPE – Bruch’s membrane volume (Spectralis – Heidelberg, Heidelberg, Germany) following by manual corrections (control = 0.1±0.01)(AMD = 0.16±0.06) (μm³; mean ± SD). Relationships were evaluated using Kruskal-Wallis test of medians and Pearson’s correlation coefficient (r).

Results: In the control group, the average LLD was 11.5 ± 3.03 letters, and the average scotopic sensitivity across the 20° was 19.73 ± 5.08 dB. For the early AMD group, LLD was 16.4 ± 10.4 letters, and the sensitivity was 19.40 ± 7.31 dB, in the intermediate group, LLD was 15.2 ± 6.24 letters, and the sensitivity was 19.31 ± 3.83 dB. For the GA group the LLD was 18.0 ± 9.18 letters, and the sensitivity was 16.4 ± 4.93 dB. However in the AMD groups there was no significant correlation between LLD and scotopic sensitivities (r=0.124, p=0.929). In regards to contrast sensitivity under normal and low luminance, there were correlations between VA and AULCSF (r=0.69; r=.76). However, low-luminance deficit scores calculated for VA and AULCSF were not correlated (r = -0.02). While there was no statistically significant difference in normal luminance VA between control and AMD (p=0.68), AULCSF at both normal (p=0.02) and low luminance (p=0.005), and VA at low luminance (p=0.04), showed statistical differences between control and AMD subjects. While there was a statistical difference in drusen volume between control and AMD patients (p=0.02), in the AMD subjects there was no correlation between drusen volume and VA and AULCSF either under normal or low luminance conditions.

Conclusions: The present findings suggest that rod and cone dysfunction in dry AMD appear to be disconnected and that that photoreceptor dysfunction in AMD may be distinct from drusen accumulation.
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**Purpose:** There is a great need for better functional outcome measures in AMD. Dark-adaptation (DA) maybe a useful functional parameter for both detection and severity of AMD. This study aims to evaluate the Structure function correlation of Dark adaptation and SD-OCT in patients with AMD.

**Methods:** Cross-sectional study, including patients with AMD and a control group (> 50 years) without any vitreoretinal disease. All participants were prospectively recruited, imaged with color fundus photographs and SD-OCT. Both eyes were tested with the AdaptDx® DA extended protocol (20 minutes). A software program was developed to map the DA testing spot (5 degree superior to fovea) on the OCT B-scans. Two independent graders evaluated the B-scans’ regions included in this spot, as well as in the entire macula, and recorded the presence of several AMD-associated abnormalities. Multilevel mixed effect linear models (accounting for correlated outcomes between 2 eyes) were used for analyses, considering rod-intercept time (RIT) as the outcome.

**Results:** We included 137 eyes (n=77 subjects), 72.3% with AMD and the remaining controls. OCT structural abnormalities were observed within the DA testing spot in 44.5% of the eyes, and in the entire macula in 71.5%. Multivariate analysis revealed that adjusting for age and AMD stage, the presence of any abnormalities within the DA testing spot (β=4.8, p<0.001), as well as in the macula (β=2.4, p=0.047), were significantly associated with delayed RIT. In eyes with no structural changes within the DA testing spot (n=76, 55.5%), pathology in the remaining macula was associated with delayed RIT (β=2.00, p=0.046). The presence of subretinal drusenoid deposits was a consistent predictor of delayed RIT, whether located within the DA bleached area (β=3.51, p=0.001), or anywhere in the macula (β=3.19, p<0.001). Within the testing spot, the presence of ellipsoid disruption, classic drusen and serous PED were also significantly associated with delayed RIT (p≤0.018).

**Conclusions:** Our results suggest a strong association between Macular structure evaluated by SD-OCT and time to dark-adapt, indicated by delayed RIT. Dark-adaptation is a good indicator of abnormality in the entire macula and not just within the test area. Subretinal drusenoid deposits appear to significantly impair dark adaptation.
Function Follows Form


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Purpose: (i) To compare ellipsoid zone (EZ) loss and functional loss in macular telangiectasia (MacTel) type 2 longitudinally. (ii) To determine the effective dynamic range (EDR), retest reliability, and number of discriminable steps (DS) for mesopic and dark-adapted two-color fundus-controlled perimetry (FCP) using the S-MAIA (Scotopic-Macular Integrity Assessment) "micro-perimeter."

Methods: Ellipsoid zone loss was measured in en-face images created from spectral domain optical coherence tomography. Functional loss was assessed by best-corrected visual acuity and microperimetry, counting the number of test points with impaired function. Each of 52 eyes of 52 subjects with various macular diseases (mean age 62.0 ± 16.9 years; range, 19.1-90.1 years) underwent duplicate mesopic (achromatic stimuli, 400-800 nm), dark-adapted cyan (505 nm), and dark-adapted red (627 nm) FCP using a grid of 61 stimuli covering 18° of the central retina. The EDR, the number of DS, and the retest reliability for point-wise sensitivity (PWS) were analyzed. The effects of fixation stability, sensitivity, and age on retest reliability were examined using mixed-effects models.

Results: A total of 56 eyes of 31 participants were followed for 4.5 ± 1.2 years. Ellipsoid zone loss was 18,600 ± 3,917.3 pixel at baseline (=0.59 mm) and increased 2,627.8 ± 427.9 pixel (=0.08 mm) per year. Best-corrected visual acuity decreased 2.2 ± 0.9 letters per year. Change in EZ loss correlated significantly with change in relative and absolute scotomas (r = 0.62; P-value < 0.0001 and r = 0.72; P-value < 0.0001), but not with loss of best-corrected visual acuity. Functional loss showed a similar frequency of progression as EZ loss, but a higher rate of "regression," likely due to higher variability of the measurement, assuming a progressive neurodegenerative disease. The EDR was 10 to 30 dB with five DS for mesopic and 4 to 17 dB with four DS for dark-adapted cyan and red testing. PWS retest reliability was good among all three types of retinal sensitivity assessments (coefficient of repeatability ±5.79, ±4.72, and ±4.77 dB, respectively) and did not depend on fixation stability or age. PWS had no effect on retest variability in dark-adapted cyan and dark-adapted red testing but had a minor effect in mesopic testing.

Conclusions: The results of support EZ loss as surrogate measure for visual function in MacTel type 2. Being objective, EZ loss might be considered more suitable than microperimetry as primary end point in future interventional trials. Combined mesopic and dark-adapted two-color FCP allows for reliable topographic testing of cone and rod function in patients with various macular diseases with and without foveal fixation. Retest reliability is homogeneous across eccentricities and various degrees of scotoma depth, including zones at risk for disease progression.
Type 3 Neovascularization in AMD: a Clinicopathologic Correlation Using Eye Tracked In Vivo and Ex Vivo OCT Scans

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Purpose: To correlate multimodal imaging in a case of treated type 3 (intraretinal) neovascularization (NV) secondary to age-related macular degeneration (AMD) with eye-tracked ex vivo imaging and histology.

Methods: Clinical imaging included serial near-infrared reflectance and eye-tracked spectral domain optical coherence tomography (OCT). Retinal imaging during each follow-up visit was correlated with ex vivo imaging and high-resolution histologic images of the preserved donor eye, which was recovered 4 months after the last visit with treatment.

Results: An 86-year-old white woman with type 3 NV secondary to AMD was treated with 6 intravitreal injections of bevacizumab. Eye-tracking of clinical in vivo images showed progressive resolution of the exudative component, with persistent focal outer retinal hyperreflectivity. Comparison of in vivo and ex vivo OCT scans with histology enabled identification of histologic correlates for clinical OCT signatures, including reflectivity of the neovascular complex, intraretinal hyperreflective foci and intraretinal cellularity, analysis of the topography of pathology, and evaluation of the sub-retinal pigment epithelium (RPE)-basal lamina (BL) space.

Conclusions: Clinicopathologic correlation of type 3 NV showed vascular elements of retinal origin associated with collagenous material and Müller cell processes implanting deep into thick sub-RPE basal laminar deposit, without evidence of chorioretinal anastomosis. Surrounding RPE-derived and lipid-filled cells thought to be microglia correlated with clinical intraretinal hyperreflective foci. Eye-tracked OCT facilitates subcellular-level clinicopathologic correlation.
Influence of Optic Disc Morphology on BMO-MRW Analysis

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Purpose: To investigate the influence of the position of the central retinal vessel trunk exit, one of the most prominent disc features, on the location of structural glaucomatous damage for Bruch’s membrane opening minimum rim width (BMO-MRW) and peripapillary retinal nerve fiber layer thickness (RNFLT).

Methods: In this study one hundred seventy-three eyes consisting of 31 healthy control patients, 40 patients with ocular hypertensive, 47 patients with preperimetric glaucoma and 55 patients with perimetric glaucoma were included. With all patients and healthy controls, we performed standard white on white visual field examinations, optic disc photographs, and a spectral domain optical coherence tomography (SD-OCT, Spectralis, Heidelberg Engineering, Germany). The SD-OCT images were analysed using the Image-J software. The vessel exit position was determined in relation to BMO MRW centroid and structural SD-OCT parameter were compared for four subgroups were analysed in superonasal, nasal, inferonasal and temporal central vessel exit considering different glaucoma stages.

Results: The mean BMO-MRW of the healthy controls was 298,1 ± 79,15 μm, 293,4 ± 65,26 μm in the ocular hypertensive group, 213,7 ± 56,68 μm for patients with stage I, 153,5 ± 29,31 μm for stage II patients and 131,3 ± 46,82 μm for patients staged into group III and IV. The mean inner peripapillary RNFL of the controls was 93,4 ± 8,72 μm, 94,1 ± 12,09 μm in the ocular hypertensive group, 77,6 ± 13,69 μm for subjects with stage I, 61,3 ± 10,18 μm for stage II subjects and 56,86 ± 13,40 μm for subjects staged into group III and IV. Loss of BMO-MRW was most pronounced inferotemporally and superotemporally in the superonasal and nasal vessel exit subgroups and inferotemporally in the temporal and inferonasal subgroups.

Conclusion: Position of the central retinal vessel trunk exit does not influence the location of structural glaucomatous damage by SD-OCT. Early glaucoma demonstrates a different structure of the papillary damage, but the vessel exit does not significantly influence the local susceptibility neither at the optic nerve head nor at the peripapillary retina. Opposed to parapapillary atrophy in glaucoma, that maybe encountered in the opposite most distant sector to the central vessel trunk exit early structure changes by SD-OCT are most frequently seen at locations of maximum RNFLT.
How to combine visual field and OCT information: Introduction to a New Glaucoma Report

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Purpose: Glaucoma is characterized by a specific pattern of anatomical (structural) and behavioral (functional) changes. In the clinic, functional changes are typically assessed with visual fields (VF) obtained with static automated perimetry, while structural changes are assessed increasingly with information obtained from OCT scans. We have two purposes here. one, to introduce a new commercial report for quickly and accurately diagnosing and understanding glaucomatous damage based upon OCT scans; two, using this report, to illustrate a method for combing information from visual fields and OCT scans.

Methods: Using the SPECTRALIS Glaucoma Module Premium Edition, a new one-page report is generated from an averaged circle scan and the cube scan of the macula with 61 horizontal b-scan. The report includes the image of the circle scan and the peripapillary retinal nerve fiber (pRNFL) thickness plot, both presented in NSTIN (nasal to superior to temporal to inferior to nasal) format; GCL and RNFL thickness maps based upon the cube scan; and these same maps presented in VF view with the locations of the 24-2 and 10-2 VF tests superimposed. The VF locations that are abnormal on the 24-2 and 10-2 VF tests can be circled on the report and compared to GCL and RNFL thinning.

Results: 1. Glaucomatous damage can almost always be seen first in the temporal half of the superior and inferior quadrants of the peripapillary retinal nerve fiber layer (pRNFL), we call the superior (SVZ) and inferior (IVZ) vulnerability zones. 2. The IVZ includes the macular vulnerability zone (MVZ). The macula is often damaged early in glaucoma. 3. The damage seen on the OCT report can vary in location, width, depth, and homogeneity. 4. This wide variety in patterns of pRNFL thinning results in a wide variety of abnormal VF patterns.

Conclusions: The patterns of glauomatous damage seen on VF can be understood by carefully examining the changes seen in the RNFL of OCT circular scans, as well as the pattern of abnormalities seen on GC and RNFL probability plots. There are important clinical implications. First, attempts to classify or stage glaucoma based upon VF will have problems. Second, to understand and diagnose glaucoma the abnormal regions of the VF and OCT plots should be topographically compared, as opposed to the current practice of using metrics such as PSD ad GHT.
Macular Analysis in Glaucoma

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With the advent of spectral-domain optical coherence tomography (SD-OCT), multilevel OCT imaging has become widely available as the optic nerve head (ONH), the retinal nerve fiber layer (RNFL), and the posterior pole can be imaged within a very short time period with current SD-OCT technology. There is ample evidence, at this point, supporting the role of SD-OCT imaging of the macula for detection of early glaucoma. Such measurements have been found to have excellent reproducibility. In addition, evidence favoring the role of macular SD-OCT imaging for detection of glaucoma progression is accumulating. In this review, I will address the following topics as related to macular OCT imaging:

- The role of SD-OCT imaging of the macula for detection of early glaucoma
- Structure-function relationships, Hood’s map
- Predicting RGC density from GCL thickness
- Preferential IPL thinning in glaucoma: is it detectable with current OCT technology?
- Variability of macular thickness measures
- Utility of various macular parameters for detection of progression and their floor effect for macular parameters
- Prediction of glaucoma progression with macular structural measures
- Longitudinal structure-function relationships and detection of progression
Anterior Segment Outflow Imaging

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Purpose: Recent AHO imaging has evolved toward live human assessment and has focused on the structural evaluation of AHO pathways and the functional documentation of fluid flow. Structural AHO evaluation is conducted using optical coherence tomography (OCT), and functional evaluation of flow is performed using aqueous angiography. Advances in structural and functional evaluation of AHO will be presented with discussion of strengths, weaknesses, and potential future directions.

Methods: Anterior segment AHO structural lumens were assessed by anterior segment optical coherence (OCT) with the Spectralis 360-degrees around an intact eye of a living human individual. Automated segmentation was developed and assessed by expert readers.

Anterior segment AHO functional flow was performed by a new method, aqueous angiography. Fluorescein or indocyanine green was introduced into the anterior chamber at physiologic pressures, and AHO was imaged using the Spectralis angiographic function. Aqueous angiography mediated guidance of trabecular bypass stents toward initially low flow regions was tested. Aqueous angiography was performed on glaucoma models. Aqueous angiography was translated from the laboratory to the operating rooms in intact eyes of living non-human primates and human subjects undergoing routine cataract surgery.

Results: Anterior segment OCT demonstrated AHO outflow pathway lumens that could be automatically segmented. Expert reading of segmentation results demonstrated excellent accuracy and inter-observer reliability. Creation of three-dimensional casts allowed the observation of the full outflow pathways in an intact eye of a living individual showing segmental Schlemm’s Canal with clear collector channel roots.

Using aqueous angiography, segmental AHO patterns were observed with multiple dyes in multiple species using post-mortem and intact eyes of living subjects. Multi-modal imaging (aqueous angiography, OCT, histology etc…) confirmed angiographic signal as representing AHO. Aqueous angiography mediated trabecular bypass in the laboratory showed improvement of angiographic outflow when targeting surgeries toward initially low flow regions. Diminished aqueous angiographic AHO was seen in glaucoma models.

Conclusion: Both structural and functional imaging of AHO can be performed. Future efforts will be directed toward synergizing these concepts, further studying glaucoma, and refining clinical applications.
**FLIO Introduction and Applications in Alzheimer’s Disease**

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**Purpose:** To investigate Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO) findings in elderly subjects with Alzheimer’s disease (AD).

**Method:** Subjects who were participating in an ongoing Alzheimer’s biomarkers analysis at Huntington Medical Research Institute were recruited for this FLIO study. A modified Heidelberg Engineering Spectralis system equipped with a pulsed laser, dual high-sensitivity detectors, and precise single photo counting cards was use to acquire the FLIO data. Thirty degree field of view images were acquired centered on the fovea. Retinal autofluorescence was excited using a 473nm blue laser light and emitted fluorescence light was detected in two wavelengths channels; short and long spectral channel (SSC, LSC). A tri-exponential decaying curve with binning factor of two was applied. The cohort was subdivided into phakic and pseudophakic groups. The correlations between multiple FLIO-derived parameters ($\tau_m$, $\tau_1$, $\tau_2$, $\tau_3$, $a_1$, $a_2$, and $a_3$) and clinical biomarker data ($\beta$–amyloid, total tau in CSF, MMES-7, MMSE-world, Montreal Cognitive Assessment (MoCA), Global Deterioration Scale (GDS), Clinical Dementia Rating (CDR), BMI, blood pressure, serum BUN/Cr, CRP, lipid profile (TG, total cholesterol, LDL, HCL, VLDL), homocysteine, HbA1c) were assessed.

**Results:** A total of 30 eyes from 16 AD subjects (79.3±11.0) were included in this analysis. Eight subjects were phakic with no or mild cataract and 8 patients were pseudophakic, bilaterally. Among the clinical biomarkers, $\beta$ – amyloid in the CSF, serum Creatinine (Cr), CRP, and total cholesterol level demonstrated a correlation with FLIO parameters in the phakic group. In fact, every FLIO parameter showed some correlation with more than one clinical biomarker. The $\tau_m$ in both spectral channels and the $a_3$ in the LSC, in particular, showed strong correlations. In the pseudophakic group, $\beta$ – amyloid and total tau in the CSF were correlated with $\tau_2$ and $\tau_3$ of the LSC. MMSE “world” demonstrated a better correlation with FLIO parameter than the MMSE 7. BUN/Cr, CRP, lipid profile and homocysteine also showed significant correlation with FLIO parameters. Overall, correlations were stronger in the pseudophakic group compared to the phakic group. In the multivariate analysis, CSF $\beta$–amyloid, serum creatinine, CRP and lipid profile were correlated with $\tau_m$, $\tau_1$ and $\tau_2$ in the phakic group. For the pseudophakic group, MMSE world, lipid profile and homocysteine level were correlated with $\tau_3$.  

**Conclusion:** Multiple FLIO-derived parameters appear to correlate with other biomarkers in patients with Alzheimer’s disease. If these findings can be validated in future longitudinal studies, FLIO may prove to be useful as a non-invasive diagnostic tool for these patients.
Assessing Changes in Macular Telangiectasia Type 2 (MacTel) Using Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO)

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Purpose: To investigate fundus autofluorescence (FAF) lifetimes in patients with macular telangiectasia type 2 (MacTel) using Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO).

Methods: 27 patients with MacTel (mean age 60.1 ± 12.1 years), 42 healthy control eyes (mean age 60.1 ± 13.6 years), as well as 24 immediate MacTel family members (mean age 36.7 ± 16.4 years) were included in the study. FLIO (Heidelberg Engineering, Heidelberg, Germany) was used to detect FAF decays from a short (498-560 nm, SSC) and a long (560-720 nm, LSC) spectral channel. We investigated the mean fluorescence lifetime, $\tau_m$, as well as macular pigment measurements, macular OCT scans, blue-light reflectance images, fundus photographs, and fluorescein angiograms.

Results: FLIO shows a unique pattern of prolonged FAF lifetimes in patients with MacTel. While early stages show a crescent-shaped prolongation of $\tau_m$ at the temporal side of the fovea, advanced stages show an oval shaped and ring-like pattern. $\tau_m$ of the temporal para-foveal region (SSC: 382 ± 81 ps) is significantly prolonged as compared to healthy controls (SSC: 298 ± 84 ps). The affected region presents with especially high contrast, even in minimally affected individuals. In some cases of clinically normal family members, FLIO shows changes suggestive of MacTel.

Conclusions: Retinal changes in patients with MacTel can be detected with high contrast by using FLIO. Even very early stages present a distinctive signature that may be a characteristic finding of the disease. As the clinical diagnosis can be challenging due to retinal imaging of early stages often being unremarkable, the non-invasive FLIO provides a valuable addition to clinical assessment of early changes in the disease. This will possibly result in a more accurate or even earlier diagnosis of MacTel.
Monitoring Carotenoid Fluorescence with Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO)

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Purpose: To investigate fundus autofluorescence (FAF) lifetime characteristics of ex vivo carotenoids and in vivo macular pigment patterns in various patient groups using Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO).

Methods: FLIO (Heidelberg Engineering, Heidelberg, Germany) detects the mean fluorescence lifetime \(\tau_m\) from a short (SSC: 498-560 nm) and a long (LSC: 560-720 nm) spectral channel. FAF lifetimes of lutein and zeaxanthin were measured in a cuvette in both free and protein-bound states. In vivo measurements were performed in young healthy subjects (31 eyes), albinism (two eyes), macular telangiectasia type 2 (58 eyes), retinitis pigmentosa (65 eyes), and one macular hole. Macular pigment was additionally investigated with dual wavelength autofluorescence imaging.

Results: MP inversely correlates to foveal FAF lifetimes in FLIO (SSC: \(r=-0.608; \ p<0.001\)). Different distribution patterns can be assigned to specific disease-related changes. A patient with albinism, who lacks MP, was found to be missing short FAF lifetimes. Lutein (L) and zeaxanthin (Z) in solution show very short autofluorescence lifetimes (SSC: L: 52 ps, Z: 54 ps), but the decay times shift to longer means when bound to specific binding-proteins (SSC: L: 68 ps, Z: 148 ps).

Conclusions: Different retinal diseases show unique patterns of MP, which can be visualized with FLIO. In vivo \(\tau_m\) from the healthy macula shows similar FAF lifetimes to protein-bound ex vivo carotenoids. This supports the assumption of carotenoid fluorescence from the human fovea in vivo.
Fluorescence Lifetime Imaging Ophthalmoscopy of Drusen in Age Related Maculopathy

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Purpose: Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO) is a promising new imaging modality measuring autofluorescence lifetimes of endogenous retinal fluorophores.

Methods: Fluorescence lifetime imaging was performed with FLIO (Heidelberg Engineering, Heidelberg, Germany). Autofluorescence was induced using a 473 nm blue laser source and lifetimes were measured in a short (498–560 nm) and in a long (560–720 nm) spectral channel. Fluorescence lifetime data was compared with corresponding fundus autofluorescence intensity images, spectral domain optical coherence tomography (OCT) and color fundus images in patients with early and intermediate AMD.

Results: 64 eyes from 64 patients with AMD and retinal drusen (age: mean±SD 78±8.5 years; range 59-94 years) were investigated and compared to 20 age matched healthy controls. Mean retinal autofluorescence lifetime in patients with AMD was significantly prolonged compared to the healthy control eyes (mean±SEM; SSC 486±18ps vs 332±11ps, p>0.0001; LSC: 493±9ps vs 382±17ps, p>0.0001). Areas of drusen featured a broad range of fluorescence lifetime values. Long lifetimes were identified in areas of atrophy and intraretinal hyperreflective deposits identified by OCT. Areas of short lifetime corresponded to deposits within the photoreceptor outer segment band.

Conclusions: Mean retinal autofluorescence lifetimes in AMD were significantly prolonged compared to healthy and age matched eyes. Intraretinal deposits caused prolonged lifetimes whereas deposits in the area of the outer photoreceptor segments lead to short fluorescence lifetimes.
OCT Angiography: Introduction and Practical Applications

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OCT angiography is used increasingly in the clinic and in clinical research studies to diagnose retinal diseases. The optimal method to use this technology remains to be clearly defined. The clinician and researcher needs to be aware of the unique advantages and limitations of this technology to use it effectively. Advantages include the ability to see blood flow and vascular architecture in a depth-resolved manner, free of confounding vascular leakage. Limitations include artifacts such as projection and motion artifacts that can lead to misdiagnosed pathology, small field of view, and inability to assess vascular leakage. It is essential to review cross sectional structural OCT B scans with superimposed flow signals to assess location of vessels and to better identify artifacts. In the clinic, OCTA is used most efficiently when the clinician uses it as part of a multimodal assessment of the retina, rather than as a screening tool that is used in isolation, and on every patient. Practical examples will be provided to illustrate methods to identify artifacts, and to show how OCT angiography can be used to diagnose and monitor retinal diseases. Data from current and clinic trials will further inform the clinician on the best way to use OCT angiography in the clinical and in clinical trials.
Imaging the Deep Choroidal Vessels

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Purpose: To evaluate and characterize optical coherence tomography angiography (OCTA) detection of blood flow in the deeper large choroidal vessels in eyes without pathology or with various ocular disorders.

Methods: Retrospective cross-sectional analysis of 395 eyes of 275 consecutive patients with various ocular disorders and normal controls. Image acquisition was performed with either spectral domain (SD) OCTA (Zeiss Cirrus Angioplex or Optovue Angiovue) or swept source (SS) OCTA (Topcon Triton). Integrity of retinal pigment epithelium (RPE), structural visualization of deep choroidal vessels on en face imaging, and choroidal blood flow signal were analyzed.

Results: En face imaging allowed for structural visualization of choroidal vessels in all eyes. However, in both SD OCTA and SS OCTA, blood flow signal in large deep choroidal vessels was only detected in eyes with overlying RPE atrophy (100% of eyes with RPE atrophy, vs 28.6% of all imaged eyes, p < 0.001).

Conclusions: While large deep choroidal vessels structure can be seen by en face imaging in all eyes, detection of choroidal blood flow is severely limited in the presence of intact RPE. Atrophy of overlying RPE pigment unmasks choroidal blood detection in OCT angiography. Thus, intact RPE acts as a barrier for reliable detection of choroidal flow using current OCTA technology, in most eyes.
Optical Coherence Tomography Angiography (OCT-A) Helps Defining Details of Choroidal Neovascularization (CNV) on High-Speed Indocyanine Green Angiography (HS-ICG)

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**Purpose:** Identifying the presence and vascular structures of CNV is critical to effective therapy decision. The role of the present study was to determine the role of OCT-A in delineating the presence, composition and extent of CNV in patients undergoing HS-ICG examination.

**Methods:** Subjects with suspected CNV as evidenced by the appearance of subretinal or intraretinal fluid using spectral domain OCT were examined. Patients with age-related macular degeneration (AMD) (n=6), pigment epithelial detachment (PED) (n=3) or central serous choroidopathy (CSC) (n=3) underwent standard HS-ICG (Spectralis; Heidelberg Engineering) and the presence of CNV, dimensional extent, presence of mature vascular complexes, polypoidal choroidopathy and delineation of afferent and efferent feeding vessels were identified. Simultaneously OCT-A (Heidelberg Engineering) was performed under institutional review board approval. Similarly presence, extent and vascular composition of the CNV were delineated.

**Results:** In subjects with AMD and CSC, OCT-A allowed easier identification of CNV than with standard HS-ICG. However OCT-A did not allow for identification of flow patterns within the CNV that were identified by HS-ICG. In patients with PED, HS-ICG more consistently identified the presence, composition and extent of CNV compared with OCT-A.

**Conclusions:** The present findings suggest that OCT-A may be a useful adjunct to HS-ICG in the examination of patients with CNV.
Colocalization of In-Vivo Mechanical Strain and Ocular Perfusion

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Purpose: To quantify the in-vivo mechanical deformations of the optic nerve head (ONH) associated with variations of IOP and intracranial pressure (ICP). To colocalize mechanical deformations and neuroretinal rim perfusion by means of OCT-A.

Methods: The ONH of 2 eyes from 2 normal brain-dead organ donors (BDD) was imaged with Spectralis OCT-A. Anterior chamber cannulation was used to induce changes in the IOP. Five high-density 10x10 OCT-A centered on the ONH scans were recorded at 10, 30, and 50 mmHg with the body imaged in reclined position, and at 10 and 30 mmHg in supine position. Body position was changed from reclined to supine to induce an increase in ICP, while maintaining a constant IOP of 10mmHg. Each OCT-A scan was custom aligned and processed for deep tissue visibility enhancement. 3D mechanical deformations were computed by a custom digital volume correlation (DVC) procedure that included masking of the vasculature location obtained from the OCT-A.

Results: Sizable variations in the mechanical deformations of the ONH were associated with IOP and ICP increases. In particular, IOP increase induced a large compression of the pre-laminar tissue and the decrease in ICP resulted in a change in the mechanical deformations similar to that caused by an IOP increase. The 3D strain around the vasculature of the ONH was successfully resolved, and substantial mechanical compression of the ONH vasculature was associated with IOP increase.

Conclusions: We estimated the vivo mechanical deformations of the ONH caused by a changes in both IOP and ICP under manometric control, by means of Spectralis OCT-A. High mechanical strain levels were observed in the pre-laminar tissue and around vasculature. Quantification of the mechanical deformations caused by changes in IOP and ICP colocalized with ocular perfusion may be a valuable imaging protocol for the diagnosis and treatment of glaucoma.
Macular Pigment

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Macular pigment (MP) is a blue-absorbing pigment. One of the technique for estimating the density of the human macular pigment noninvasively takes advantage of the autofluorescence of lipofuscin, which is normally present in the human retinal pigment epithelium. Stimulating the fluorescence with two wavelengths, one well absorbed by macular pigment (BAF) and the other minimally absorbed by macular pigment (GAF), we can make accurate single-pass measurements of the macular pigment density. There are a series of pathologies where macular pigment can be important such as macular teleangectasis, or in case of drug toxicity.

Purpose: to describe all the methods for measuring macular pigment and evaluate some of diseases.

Methods: review the literature and measure using a double wavelength autofluorescence the macular pigment of patients with normal and different diseases such as juxtofoveal teleangectasia, tamoxifen toxicity.

Results: Macular pigment as a higher variability in normal. It does not correlate with age. However in pathologies such as Tamoxifen toxicity, macular teleangectasia the macular pigment is reduced.

Conclusions: Macular pigment measurement can be a new method for helping in differential diagnosis.
**Ischemic Optic Neuropathies**

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**Purpose:** Ischemic optic neuropathies (ION), including non-arteritic (NAION) and arteritic (AAION) forms, comprise common causes of non-glaucomatous optic neuropathy in older adults, yet the pathophysiology of these conditions remains enigmatic. Optical coherence tomographic angiography (OCT-A) is an emerging, non-invasive method to study the microvasculature of the posterior pole, including the optic nerve head. We hypothesized new and valuable information about the vascular changes in the optic nerve head and peripapillary region associated with ION would be revealed using OCT-A.

**Methods:** We performed OCT-A in 25 eyes (7 acute and 18 non-acute) in 19 patients with NAION and 5 eyes in 4 patients with acute AAION. For NAION, macro- and microvascular densities were quantified in the papillary and peripapillary regions of unaffected, acutely affected, and non-acutely affected eyes and compared across these groups according to laminar segment and capillary sampling region, and with respect to performance on automated visual field testing. OCT-A images of eyes affected by AAION were assessed qualitatively.

**Results:** In eyes acutely affect by NAION, OCT-A revealed a statistically significant reduction in the quantified signal from the major retinal vessels and dilation of the superficial capillaries in the peripapillary area. By contrast, eyes non-acutely affected by NAION showed attenuation of the capillaries in the peripapillary area. The peripapillary choriocapillaris was obscured by edema in acute cases, but was similar between non-acute and unaffected eyes with NAION. The degree of dilation of the superficial microvasculature in the acute phase and attenuation in the non-acute phase each correlated inversely with visual field performance. The region of reduced capillary density correlated with the location of visual field defects in 80% of acute cases and 80% of non-acute NAION cases. Among eyes affected by AAION, superficial peripapillary capillary dilation was seen in 5/5 eyes and 2 eyes that were clinically felt to be unaffected by AAION. Superficial capillary dilation corresponded specifically in one patient to an area of choroidal non-perfusion seen on fluorescein angiography. Follow-up OCT-A in two patients revealed progression to superficial peripapillary capillary attenuation that corresponded with visual field loss.

**Conclusions:** OCT-A reveals a dynamic shift in the superficial capillary network of the optic nerve head with strong functional correlates in both the acute and non-acute phases of both NAION and AAION. Further study and characterization of ION using OCT-A could facilitate prognostication and help guide enrollment in clinical trials for future therapeutics and improve our ability to counsel patients.
OCT Angiography and Exudative ARMD –
New Insights into the Clinical Diagnosis and Treatment

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Purpose: OCT Angiography reveals enhanced B scan imaging as well as flow analysis that segments Exudative ARMD into several different subtypes, each which has diagnostic and therapeutic significance.

Methods: Retrospective, non-randomized study of 474 patients with treatment-naive and treated Type 1 Exudative ARMD who were evaluated by OCTA (Heidelberg Beta Version). Exclusion criteria involved concurrent vasculopathies, optic neuropathies, and/or the presence of previous vitrectomy. Preoperative VA, OCT, IOP, IVFA/ICG Videoangiography and OCTA were performed. Correlation to VA, degrees of subRPE, subretinal and intraretinal exudation, heme, and changes in OCTA were determined to evaluate new biomarkers for segmenting patients with Exudative ARMD.

Results: 84.2% of the 474 patients with Type 1 Exudative ARMD had distinct CNV noted on OCTA. These lesions were less apparent on ICG videoangiography and not appreciated at all on IVFA. 15.8% did not have CNV on OCTA. 44.2% had the pachychoroid spectrum of disease – 19.3% of these patients did not have CNV – 80.7% had evidence of CNV.

Conclusion: OCTA provides a higher quality image of CNV compared to ICG Videoangiography. OCTA shows that patients with the pachychoroid spectrum of disease are very likely to harbor CNV. These patients may not respond to PDT – they may require anti-VEGF for exudative resolution.
Ultra-High Resolution Cross-Sectional OCT-Angiography of Retinal and Choroidal Neovascularizations: Infrared and Multicolor Guided Assessment

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\textbf{Purpose}: To evaluate the capability of an integrated label-free approach based on Multicolor (or infrared) imaging combined with Ultra-high-resolution cross-sectional OCT-Angiography (UHR OCT-A) to detect and characterize retinal and choroidal neovascularization.

\textbf{Methods}: Clinically suspect retinal or choroidal neovascularizations were assessed with Fluorescein angiography (FA), indocyanine green angiography (ICGA), and multicolor (or infrared) imaging guided UHR OCT-A (based on Spectralis OCT2, Heidelberg Engineering, Heidelberg, Germany) to define the presence, type, location and status of the lesions. The different outcomes from each single imaging modality were separately assessed in order to detect sensitivity and specificity. An integrated assessment of the different findings was also performed in order to define the best potential imaging protocol in different retinal and chorioretinal diseases.

\textbf{Results}: One hundred and two (102) eyes of 86 consecutive patients, suffering from different retinal and chorioretinal diseases with suspected neovascular (NV) lesions were enrolled. In the overall analysis multicolor (or infrared) imaging guided UHR OCT-A resulted superior (p<0.05) to FA or ICGA in detecting the presence, characterizing the type and localizing a NV lesion. No statistically significant differences were appreciated in identifying the status (exudating/non exudating) between FA and multicolor (or infrared) imaging guided UHR OCT-A. No statistically significant differences in any of the assessed parameters were noticed between an integrated FA+ICGA approach and multicolor imaging guided UHR OCT-A.

\textbf{Conclusions}: The multicolor (or infrared) imaging guided UHR OCT-A approach showed promising in detecting the presence characterizing the type and localizing a NV lesion. Integrating conventional dye imaging with UHR OCT-A in an hybrid approach may substantially increase the diagnostic accuracy in several retinal and choroidal NV diseases.
OCT Angiography in Posterior Uveitis

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**Purpose:** To describe current clinical applications of Optical Coherence Tomography Angiography (OCTA) in posterior uveitis and emerging insights about this disease from OCTA.

**Methods:** Consecutive patients with posterior uveitis were imaged with either the Zeiss AngioPlex OCTA (Carl Zeiss AG, Oberkochen, Germany) or the AngioVue OCTA (Optovue, Fremont, CA) from February 2016 to September 2017. Diagnoses included choroidal neovascularization secondary to multifocal choroiditis, acute posterior multifocal placoid pigment epitheliopathy (APMPPE), birdshot chorioretinopathy (BCR), presumed ocular histoplasmosis syndrome (POHS), and multiple evanescent white dot syndrome (MEWDS). This study was approved by the institutional review board at Massachusetts Eye and Ear.

**Results:** OCTA was helpful in distinguishing choroidal neovascularization from foci of choroiditis. Unique patterns of choroidal hypoperfusion were observed. In POHS and MEWDS, areas of choroidal hypoperfusion correlated well with clinically observed pathology, but in APMPPE and BCR, they were more widespread.

**Conclusions:** OCTA add critical information to clinical decision-making in posterior uveitis and identify different patterns of choroidal hypoperfusion in white dot syndromes.
The Features of Macular telangiectasia type 2 (MacTel) as seen on Heidelberg Optical Coherence Tomography Angiography (OCTA)

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**Purpose:** To describe the features of Macular telangiectasia type 2 (MacTel) as seen on Heidelberg optical coherence tomography angiography (OCTA).

**Methods:** A retrospective cohort study was carried out. A log of patients who underwent OCTA on the Heidelberg spectralis was reviewed. Two groups were included; those with a definitive diagnosis of macular telangiectasia type 2, and a control group of ‘normal’ OCTAs. Exclusion criteria included significant imaging artifacts which would affect image analysis. Each layer of the retina was reviewed as defined by the automatic segmentation.

**Results:** 4 patients and 8 eyes were included in the MacTel 2 group. Male to female ratio was 1:3. Mean age was 59.8 years. All MacTel cases were at early stage (stage I or II). In the normal group 9 patients and 16 eyes were included. Mean age was 44.2 years, male to female ratios was 2:7. Changes in MacTel patients were consistent across the entire group with inspection by retinal specialist revealing an enlarged foveal avascular zone compared to normal patients, and most prominent changes being seen in the deep retinal plexus with prominent dilatations and increased intervacular spaces due to decreased capillary density. This capillary loss could be seen to a lesser extent in the superficial retinal plexus. Avascular layers were unremarkable. In one case Fundus fluorescein angiography, typically the gold standard for the diagnosis of MacTel was inconclusive, and OCTA helped confirm diagnosis.

**Conclusions:** MacTel appears to have distinct features on Heidelberg OCTA which may aid in diagnosis and monitoring of this condition.
OCT-A in Glaucoma - What Makes Sense?

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Where are we now?

- Valid internally - consistent with expected histopathology ✔
- Reproducible - improved with registration to baseline images ✔
- Diagnostically accurate ✔
- Detects change over time ✔
- Response to treatment ?

Are there limitations?

- Confounding factors (systemic medical conditions and medications)
  - may affect vessel density measures
- Rapidly changing technology
- Paucity of well-designed studies

What about the future?

- Improved acquisition techniques
  - faster speed, denser cube, longer wavelength for deep structures,
- improved motion correction and projection artifact removal
  - motion tracking, post-image processing
- larger field of view
- quantitative measurements
  - structural and vaculature analysis (co-localized) from same scan
  - improved segmentation and analysis (eg projection resolved OCT-A)
- BLOOD FLOW
First Data of OCT-A in Glaucoma

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**Purpose:** To highlight present data on the application of Optical Coherence Angiography (OCT-A) on glaucoma disease.

**Methods:** Both preliminary own data, as present literature is reviewed.

**Results:** It has recently been shown, that OCTA is able to show changes of the retinal inner vascular layer in correlation with loss of ganglion cell complex (GCL), retinal nerve fibre layer (RNFL) and visual field (VF) sensitivity. Even in early glaucoma forms sensitivity and specificity to detect glaucoma showed similar values to those of structural biomarkers as OCT measured thickness of RNFL.

After successful intraocular pressure (IOP) lowering surgery an increase of flow-parameters with OCT-A could be demonstrated.

Diagnostic caveats are all kind of other optic atrophies leading to the same effect of reduced flow parameters, so that OCT-A alone can not be used to detect glaucomatous damage.

**Conclusion:** OCT-A shows reduced flow-parameters in the peripapillary retina but there are still unsolved questions as the influence of arterial blood pressure and IOP, pupil dilating and antiglaucomatous drugs, the role of choroidal perfusion, and issues with reproducibility, image quality and projection artefacts.
**New Morphometric Biomarkers for Glaucoma in the Deep Optic Nerve Head**

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**Purpose:** SD-OCT imaging has allowed for the visualization and quantification of deep optic nerve structures that provides unique insight into glaucoma pathogenesis. Specifically, the ability to segregate the regions of neural, vascular and load-bearing connective tissues components of the optic nerve has provided opportunity to the study of the changes of the lamina cribrosa with age, glaucomatous remodeling along with its mechanical behavior in-vivo.

**Methods:** This presentation will review the findings from several SD-OCT imaging studies and analysis of post-mortem human ocular tissues focused on differences in ONH morphology and mechanical behavior with age, in glaucoma and across at-risk racial groups.

**Results:** The literature suggests that morphologic variation in the optic nerve associated with aging and race may possibly underlie predilection to develop glaucoma with age and in the at-risk African derived population. Moreover, the laminar cribrosa remolds in a complex way with aging and in glaucoma that also may differ across racial groups.

**Conclusions:** Changes in the position of the lamina cribrosa and potentially its mechanical behavior can be seen with glaucomatous progression and may be an important mechanistic biomarker to better refine glaucoma diagnostic and management.
Misconceptions about OCT and Glaucoma

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**Purpose:** There are two common misconceptions about the clinical use of OCT for diagnosing glaucomatous damage. Many clinicians and clinical scientists believe that: one, OCT cannot be used for patients with high myopia; and two, advanced glaucoma cannot be followed with OCT. The purpose here is to demonstrate that with proper analysis both are at best a gross oversimplification.

**Methods:** All eyes were tested with the SPECTRALIS Glaucoma Module Premium Edition on a SPECTRALIS HRA+OCT and with the 24-2 and/or 10-2 visual field (VF) pattern of the HFA II-i (Zeiss). For study one (high myopia), 96 eyes from 56 consecutive patients had corrected spherical refractive errors worse than -6D (-8.8 D ±2.8 D; n = 58) and/or axial lengths >26.5 mm (28.0 mm ±1.3 mm; n = 60). With all available information a glaucoma specialists judged whether each eye was glaucomatous or healthy. For Study two, 32 eyes 27 patients had a MD on 24-2 VFs worse than -15 dB.

**Results:** Study one: using only the OCT, the author was correct in 97% of the eyes. Study two: 29 of the 32 eyes show local regions of RNFL and/or GCL preservation that can be used to follow progression.

**Conclusions:** OCT can be used to diagnose and follow high myopes and patients with advanced glaucoma if standard metrics (e.g. global/average RNFL thickness) are ignored and a qualitative assessment of RNFL and GCL thickness plots is made.
Poster Presentation:

Characterization of Retinitis Pigmentosa Using Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO)

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Purpose: To investigate fundus autofluorescence (FAF) lifetimes in patients with retinitis pigmentosa (RP) using Fluorescence Lifetime Imaging Ophthalmoscopy (FLIO).

Methods: 33 patients (mean age 40.0 ± 17.0 years) with RP were included in the study. The fluorescence lifetime imaging ophthalmoscope (FLIO, Heidelberg Engineering, Heidelberg, Germany) was used to detect FAF decays in both a short (498-560 nm, SSC) and a long (560-720 nm, LSC) spectral channel. We investigated a 30° retinal field, and the mean fluorescence lifetime, \( \tau_m \), was calculated from a 3-exponential approximation of the FAF decays. In addition to FLIO imaging, macular pigment measurements, macular OCT scans, fundus photographs, visual fields and fluorescein angiograms were recorded.

Results: FLIO shows a typical \( \tau_m \) pattern in patients with RP. In peripheral atrophic regions, \( \tau_m \) was prolonged (SSC 419 ± 195 ps, LSC 401 ± 111 ps) as compared to the same region in healthy eyes (SSC 265 ± 53 ps, LSC 282 ± 43 ps). Within the relatively preserved macular region, ring-shaped patterns are found in FAF intensity and lifetime images. Patterns are most apparent in patients with RP inherited in an autosomal dominant manner and in those with Usher Syndrome. Patients with autosomal recessive inheritance show a milder pattern, and those with X-linked retinitis pigmentosa show no ring pattern.

Conclusions: FLIO presents a distinct and specific signature in eyes affected with RP. Hyperfluorescent rings with short FAF lifetimes might predict further progression of retinal atrophy.
Poster Presentation:

OCT: an Evolving Role in Neuro-Ophthalmology in South Africa

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Purpose: In an African setting where the prevalence of glaucoma is very high: it might be easy to overlook the hidden optic neuropathies. I would like to demonstrate in much detail the extraordinary capabilities of the Spectralis, in a small retrospective study.

Methods: Optical coherence tomography is an imaging technique used widely for the management of glaucoma and macular diseases. It is starting to play an evolving role in the neurologic and neuro-ophthalmologic field.

The peripapillary retinal nerve fiber layer (RNFL) thickness is the most valuable structural parameter when examining patients with neurological disease, as we can evaluate both average RNFL thickness and its thickness in different sectors.

With the development of OCT technology, it is now possible to measure also macular ganglion cell layer thickness adding an advanced segmentation algorithm. Since a significant portion of retinal ganglion cell bodies reside in the macula, a loss of tissue there helps to identify optic nerve damage.

In a small retrospective study, the diagnosis of glaucoma in certain patients were revisited with interesting results. The clinical findings lead to the diagnosis of ea. pituitary adenoma, MS, NMO and alzheimer disease. This is now only made possible because of this new technology.

Conclusions: Using case presentations I would like to demonstrate how specific optic nerves can tell a different story once you look at it from a Spectralis point of view. The precise capabilities of the Heidelberg Spectralis are shown in detailed images and follow-up possibilities in specific case studies.
Poster Presentation:

Optical Coherence Tomography Retinal Segmentation Changes Induced by Gradual Ascent to High Altitude in Mountaineers Randomized to Acetazolamide vs Placebo

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Purpose: Structural and functional changes of the human macula have been described after acute exposure to high altitude. Acetazolamide is known to reduce the incidence of acute mountain sickness. We report the effect of a gradual altitudinal ascent on retinal segmentation and subfoveal choroidal thickness (SCT) on a group of mountaineers who were randomized to acetazolamide vs placebo.

Methods: 20 healthy mountaineers who undertook an ascent from the base at Gressonay (1,640m) to Margherita Hut (4,559m) on Monte Rosa, Italy were randomized to treatment with acetazolamide 250mg BD vs placebo. Acclimatization was pursued with a first day 1,000 ascent and return to base followed by approximately 1,000 progressive ascent per day to Mount Rosa over 3 days (from 1,640m at base to 2,646m, 3,647m and 4,559m).

OCT SPECTRALIS (Heidelberg Engineering) was carried out at 1640m and at 4,599m. Fast volume 20x20° cube scans centered on the fovea and vertical and horizontal 9mm EDI crosslines scans were acquired. Changes in overall retinal thickness and 8-retinal layers segmentation were calculated using the Eyex software (Version 6.3.2). SCT was obtained as an average of vertical and horizontal manual measurements of the distance from the RPE/BM complex to the choroidal-scleral junction. All measurements were taken late afternoon-evening to minimize diurnal variation.

Results: The right eye of 20 subjects (mean age 36.4 SD±19.9 years) was included in the analysis. There was no significant difference between intervention and control groups for any retinal layer or SCT.

A statistically significant all-participant ETDRS grid mean thickness increase was seen only for RNFL 2.36 % (p = 0.006), GCL 1.18 % (p = 0.050) and OPL 2.31 % (p = 0.028). When ETDRS areas were grouped into larger and smaller vessel sectors the larger vessel group saw a significantly greater increase in mean RNFL thickness with altitude than the less vascularized group (% change 3.1 vs 0.24, p = 0.048). This difference was not present for other layers. The mean SCT decreased significantly by 8.8µm (p = 0.008).

Conclusions: Acetazolamide seems not to affect retinal and choroidal thickness changes after gradual ascent to high altitude. The RNFL contribution to increased altitudinal retinal thickness appears to be greater in sectors with larger retinal vessels. This is not the case for OPL expansion.
Poster Presentation:

Multimodality Imaging in Oncology

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Purpose: To analyze the importance of multi-imaging in the diagnosis and management of intraocular tumors and, secondly, to describe optical coherence tomography angiography (OCT-A) features of choroidal neovascularization (CNV) associated with choroidal nevus.

Methods: Retrospective observational case series. Patients with CNV secondary to choroidal nevus underwent full imaging examination including fundus photography, fluorescein angiography (FA), indocyanine green angiography (ICGA), spectral domain optical coherence tomography (SD-OCT), and OCT-A. The OCT-A features were analyzed and correlated with conventional angiography findings and SD-OCT.

Results: There were 11 eyes from 11 patients (6 male and 5 female, mean age of 65±20.4 years) included in the analysis. FA and ICGA disclosed CNV in 90% and 83%, respectively. OCT-A displayed CNV network in 11 eyes (100%) and the pattern was classified as “sea-fan” in 8 (73%) and “long filamentous linear vessels” in 3 (27%) eyes. Distinct from CNV, intrinsic vasculature within the nevus was observed in 6 eyes (55%), corresponding to those with chronic retinal pigment epithelium changes.

Conclusions: Multimodal imaging usually offers a detailed and exhaustive analysis of main intraocular tumors. Additionally, OCT-A is a useful imaging technique to disclose CNV associated with choroidal nevus with results non inferior to ICGA; this imaging modality can be useful for analysis of long-standing nevi with related exudation.

The diagnosis of intraocular tumors is typically based on a comprehensive clinical examination by means of biomicroscopy, indirect ophthalmoscopy and ultrasonography. Nevertheless, a multi-imaging approach including fundus autofluorescence (FAF), fluorescein angiography (FA), indocyanine green angiography (ICGA) and, in particular, enhanced depth imaging-optical coherence tomography (EDI-OCT) has guaranteed in the last decades a better understanding of the pathogenesis of several conditions improving also our diagnostic capability. More recently, optical coherence tomography angiography (OCT-A) has been used for visualizing retinal and choroidal vasculature with no need for dye injection. Herein, we analyze the imaging features of choroidal neovascularization (CNV) associated with choroidal nevus by means of OCTA. Additionally, the use of multi-imaging in the diagnosis and management of main choroidal tumors as well as some illustrative cases will be discussed.
Poster Presentation:

Diabetic Choroidopathy with Swept-Source Optical Coherence Tomography

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Purpose: To compare choroidal vascular density (CVD), choroidal thickness (CT), and choroidal vascular volume (CVV) between eyes of diabetic patients with different stages of disease and controls, using swept-source optical coherence tomography (SS-OCT).

Methods: Cross-sectional, prospective, multi-center study including patients with different stages of diabetic retinopathy (DR) and age-matched controls. Diabetic eyes were divided into four groups: no DR, non-proliferative diabetic retinopathy (NPDR), NPDR with macular edema, and proliferative DR (PDR). All patients underwent a full ophthalmologic exam and imaging using SS-OCT. En face images of the choroidal vasculature were obtained and converted to binary images using ImageJ. CVD was calculated using as a percent area occupied by the choroidal vessels in the central macular region, as well as in posterior pole. The central macular CVV was calculated by multiplying the average CVD by macular area and CT (obtained with automated SS-OCT software). Multilevel mixed linear models were used for analyses.

Results: Compared to controls (30.9% ± 7.2%), central macular CVD was significantly decreased by 9% in eyes with NPDR with macular edema (28% ± 6.1%; ß=-0.03, p=0.02) and by 15% in PDR (26.4% ± 5.1%; ß=-0.04, p=0.01). The central macular CVV was significantly decreased by 19% in eyes with PDR (0.020 mm³ ± 0.005 mm³, ß = -0.01, p=0.01) compared to controls (0.025 mm³ ± 0.01 mm³).

Conclusions: CVD and CVV are significantly reduced in diabetic retinopathy, with increasing reductions being observed with increasing levels of diabetic retinopathy. New imaging modalities, like SS-OCT, might allow increasing the current knowledge on the contributions of choroidal vessel disease to diabetic eye disease pathogenesis, prognosis, and treatment response.