Resident and Fellow Research Day 2024

Department of Ophthalmology and Visual Sciences
University of Iowa Carver College of Medicine

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Session I – Paper 1

Joanna Silverman, MD | *Is Suction-based Tectonic Stabilization Protective Against Endothelial Loss? Rethinking the Standard of Care for Corneal Donor Recovery*

Primary Supervisor: Christopher Sales, MD, MPH

Co-authors: Noah Healy, MS; Simran Sarin, BA

Purpose: U.S. eye banks recovered 86,986 corneas from deceased donors for keratoplasty in 2023. Allograft longevity is highly dependent on post-recovery endothelial cell count. Endothelial loss, specifically, is variable amongst eye banks, recovery technique (published loss ranges 1.4%-11.1%), and technician skill level, and is largely a consequence of mechanical corneal distortion during recovery. Previous studies have validated procedural curricula in improving recovery quality amongst technicians. However, there have been fewer efforts to augment existing procedures to reduce mechanical strain on donor corneas. Furthermore, there is a growing need to deskill recovery given the global burden of corneal blindness and absence of robust eye banking systems in locations of greatest need. In this study, we sought to determine whether suction-based mechanical stabilization of the corneoscleral button during recovery was protective against endothelial loss compared to current standard operating procedures (SOPs).

Methods: A series of corneal suction devices were iteratively generated based on the Barron Vacuum Donor Cornea Punch. Device performance was assessed by consistent maintenance of position/suction over the corneoscleral button throughout recovery. A standard 15 mm diameter scleral contact lens (SCL) (SynergEyes) was observed to superiorly maintain position/suction and was selected for intervention. Matched donor pairs were recovered in parallel using either 1) modified Iowa Lions Eye Bank SOPs or 2) pre-placement of SCL prior to the same modified SOPs. Post-recovery cell loss was quantified utilizing Trainable Weka Segmentation (ImageJ) analysis of endothelial staining patterns with trypan blue.

Results: Twelve eyes from 6 donors were recovered for this study. Mean donor age was 58.8 (± 16.8) years and mean death-to-preservation time was 13.6 (± 7.2) hours. Two donors had pre-mortem history of intraocular surgery. SCL-recovered corneas trended towards less endothelial loss (9.4±5.2 %), albeit insignificantly, compared to SOP-recovered matched pairs (14.1±6.1 %) (p=0.12). With respect to qualitative endothelial staining patterns, SOP-recovered eyes demonstrated more frequent/longer peripheral endothelial stress lines and central punctate loss compared to their stabilized counterparts.

Conclusions: Suction forces provided by a scleral lens may provide sufficient stabilization of the corneal contour to reduce endothelial cell loss during donor recovery.

Session I – Paper 2

Brandon Baksh, MD and Matthew Meyer, MD | *The Effect of Intraoperative Intraocular Pressure Settings on the Rate of Post-Cataract Surgery Cystoid Macular Edema*

Primary Supervisor: Jaclyn M. Haugsdal, MD

Co-authors: Thomas Oetting, MD; Mahsaw Mansoor MD; Jonathan Trejo, MD; David Chenoweth, BS

Purpose: To review the outcomes of cataract surgery at the University of Iowa. We aim to analyze different phacoemulsification settings and any post-operative complications, particularly cystoid macula edema (CME).

Methods: We will conduct a chart review of all patients who underwent phacoemulsification with intraocular lens implant from 6/1/2022 to 1/1/2024 at the University of Iowa. We will identify the phacoemulsification settings used and incidence of cystoid macular edema (CME). We will also note any significant complications, preexisting comorbid conditions, history of prior eye surgeries, and type of intraocular lens implanted. Patients with prior CME will be excluded from the study.

Results and Conclusions: In progress and pending completion of the study.

Session I – Paper 3

Mahsaw Mansoor, MD | *Cost Savings in Multidose Protocol for Cataract Surgery: A Pilot Study at UIHC*

Primary Supervisor: Jaclyn Haugsdal, MD
Co-author: Thomas Oetting, MD

Purpose: Unnecessary waste of perioperative ophthalmic medications increases institutional costs and contributes to the disproportionately large carbon footprint in cataract surgery. Beyond economic and environmental burden, there is a need to move toward sustainability in the era of drug shortages. The purpose of the current study is to calculate the potential cost savings and carbon footprint reduction associated with transition to a multiuse perioperative eyedrop protocol at the University of Iowa.
Methods: This was a retrospective economic and scenario analysis of routine cataract surgery patients at the University of Iowa Hospitals (Iowa City, Iowa) over a two-year period. Institutional cost in US dollars was modeled in a simulated multiuse eyedrop protocol versus the current protocol in which topical medications consisting of cyclopentolate 1%, phenylephrine 2.5%, and ketorolac 0.4% are discarded after single use.
Results: A total of 3,450 routine cataract surgeries were performed at the University of Iowa from 2021 to 2022. A multiuse perioperative topical medication protocol allowed for a 97% reduction in the number of bottles of medication (3,450 bottles versus 106 bottles). This led to an estimated $335,649.15 in cost savings over the two-year period.
Conclusions: Single use topical ophthalmic eyedrop protocols are a large contributing factor to the significant financial and environmental waste of cataract surgery. Transitioning to a multiuse eyedrop protocol offers significant cost savings and a reduction in carbon emissions. Current work to implement a multiuse eyedrop protocol at UIHC is underway.

Medication	Institutional Cost per Bottle	Bottle Volume	Uses with 50µL per drop	Patients per bottle*	Bottle Count Single Use FY2021	Bottle Count Multiuse FY2021	Bottle Count Single Use FY2022	Bottle Count Multiuse FY2022
Cyclopentolate 1%	$11.17	2 mL	40	13	1,407	109	2,043	158
Phenylephrine 2.5%	$78.73	15 mL	300	100	1,407	15	2,043	21
Ketorolac 0.4%	$42.78	5 mL	100	33	1,407	43	2,043	63

Table 1. Comparison of Actual Bottles Used versus Estimated Number of Patients per Bottle Based on Individual Drop Volume in a Multiuse Model. *****An assumption of 3 eyedrops per patient was made in estimating the number of patients per bottle.

	Fiscal year 2021 (n = 1,407)	Fiscal year 2022 (n = 2,043)	Total Cost
Institutional Cost in Single Use Model			
Cyclopentolate 1%	$15,716.19	$22,820.31	$38,536.50
Phenylephrine 2.5%	$110,773.11	$160,845.39	$271,618.50
Ketorolac 0.4%	$14,618.73	$21,226.77	$35,845.50
Institutional Cost in Multi Model			
Cyclopentolate 1%	$1,217.53	$1,764.86	$2,982.39
Phenylephrine 2.5%	$1,180.95	$1,653.33	$2,834.28
Ketorolac 0.4%	$1,839.54	$2,695.14	$4,534.68
Potential Cost Savings			
Cyclopentolate 1%	$14,498.66	$21,055.45	$35,554.11
Phenylephrine 2.5%	$109,592.16	$159,192.06	$268,784.22
Ketorolac 0.4%	$12,779.19	$18,531.63	$31,310.82

Table 2. Comparison of Actual Institutional Cost versus Estimated Cost in Multiuse Model. Cost savings are estimated as the difference between the two protocols.

Session I – Paper 4

Marina Peskina, MD | *How Can Jell-O Help with DMEK Surgery?*

Primary Supervisor: Christopher Sales, MD

Co-authors: Myles Evangelista, MS; Kristan Worthington, PhD; Britanny Allen, BS; Noah Healy, MS

Purpose: To develop a temporary support material to protect Descemet membrane endothelial keratoplasty (DMEK) tissue and reduce its scrolling during transplantation.

Methods: Pairs of 8-mm diameter DMEK donors of ages < 40 (*n* = 1 pair), 40 – 60 (*n* = 2 pairs), and > 60 years old (*n* = 2 pairs) were studied. In each pair, the right eye was treated with 40 µL of a prepolymer solution and exposed to violet light for 104 seconds to generate the scaffold. The left eye was left untreated. The grafts were then placed in a buffered saline solution where the scroll behavior was observed. Then grafts were loaded into and unloaded from a Jones tube and the adhesive and scroll-reducing properties of treated and control tissues were evaluated. At the end of the experiment, graft viability was assessed with Calcein AM viability dye (Thermo Fisher). 35% lyophilized gelatin methacrylate (GelMA) (Ronawk) was used as a prepolymer, 100 mg/ml lithium phenyl (2,4,6-trimethylbenzoyl) phosphinate (*LAP*) was used as a photoinitiator, cosmetic-grade airbrush (I-Beautee, C8+131) was used for the prepolymer application.

Results: The mean scroll width in the study and control group were 2.41 mm and 1.99 mm respectively. The difference was not statistically significant (p=0.32). Endothelial cell loss in the study and control group was 24.84%, and 41.26% respectively, with statistically significant difference (p=0.02).

Conclusions: GelMA photopolymerized under visible light does not cause damage to corneal endothelial cells. Furthermore, GelMA-treated DMEK grafts display higher corneal endothelial cells viability compared to untreated grafts. There was a positive trend in reduction of DMEK graft scrolling behavior after GelMA application. Further development of this approach has potential to improve DMEK technique.

Session I – Paper 5

Christian Mays, MD | *Compared Trabeculectomy Approaches on Surgically Induced Astigmatism*

Primary Supervisor: Andrew Pouw, MD

Co-author: Hend Al-Kaylani, BS

Purpose: The purpose of the study was to determine the postoperative change in astigmatism in primary trabeculectomies. Fluid collecting blebs can be designed differently by either crafting a conjunctival bleb approaching the fornix or approaching the limbus, both of which can cause surgically induced astigmatism (SIA). SIA can increase dependence on glasses and decrease quality of life. Although the main goal of trabeculectomy is controlling intraocular pressure, astigmatic changes during surgery that increase refractive needs and number of clinic visits are relevant in a population in which preserving vision is the final goal.

Methods: Limbus-based surgeries and fornix-based surgeries with or without a partial-thickness corneal incision were compared in this IRB-approved retrospective study. Primary trabeculectomies in this study were completed and compared at the University of Iowa Hospitals and Clinics by three faculty surgeons between October 2020 and August 2023. Exclusion criteria included absence of pre- or post-operative refraction within two years before the date of surgery, absence of intraocular pressure recording within two months before surgery, or absence of intraocular pressure recording within 5-8 weeks after surgery. Exclusion criteria included other ocular surgery done in the same eye in the timeframe between the collected pre- and post-operative refractions. Comorbidities diagnosed in the timeframe between the collected pre- and post-operative refractions, including corneal dystrophies, keratitis, ectasias, or other corneal pathologies were also excluded. If both eyes of a subject qualified, one eye was chosen randomly to minimize positive selection bias.

Results: The final analysis consisted of 87 procedures. The mean age of the sample was 73.1 ± 11.7 years. 59.8% of our study population was female. For Surgeon 1, both limbal and fornix-based approaches induced +0.75 D of astigmatism. The fornix-based approach by Surgeon 2 had a mean induced astigmatism of +1.13 D. The fornix-based approach with small limbal relaxing incision by Surgeon 3 had a mean induced astigmatism of +0.75 D. Mean induced astigmatism did not statistically differ between surgical approach (p=0.409).

Conclusions: SIA does not significantly differ between a limbus-based or fornix-based trabeculectomy. While there is excellent research comparing limbus and fornix-based trabeculectomy failure rates, changes in pressure, and number of medications required post-operatively, there is limited work comparing change in astigmatism. This study adds insight on the effect of trabeculectomy approach for SIA.

Session II – Paper 6

Tina Hendricks, MD, MSc | *Global Ophthalmology at Iowa: Initiatives and Update on Progress*

Primary Supervisor: Thomas Oetting, MD, MSc

Co-author: Kanwal Matharu, MD; Pavlina Kemp, MD; Wallace L. Alward, MD

Purpose: The University of Iowa Department of Ophthalmology has a longstanding reputation for excellence in resident training and patient care. We have begun the establishment of an Institute for Global Ophthalmology at the University of Iowa through the development of a residency curriculum and distinction track, establishment of academic partnerships, and increase in local outreach efforts.

Methods/Results: Residency Curriculum: We have developed a global and local outreach distinction track within our residency that includes didactics, Manual Small Incision Cataract Surgery (MSICS) simulation, global/local fieldwork, leadership positions within the residency program, local free clinic and free cataract surgery program. Residents who complete the curriculum will earn a department-issued certificate upon graduation, attend the Global Ophthalmology Summit, and may complete an international trip within their residency. A capstone project comprising research or programmatic work may be completed for additional recognition within the curriculum.

Academic Partnerships: We have developed several notable academic partnerships. In collaboration with Orbis International, we are working with the Bangladesh College of Physicians and Surgeons (BCPS) to standardize the training of ophthalmologists across Bangladesh. Through this partnership, we aim to leveraging Iowa's historic strength in resident training into the creation of a standardized post-graduate ophthalmology curriculum across Bangladesh. Once the curriculum has been shown to improve training outcomes in Bangladesh, we hope that the web-based, free, standardized curriculum may serve to improve ophthalmology training in other developing nations.

We are also working closely and have a signed memorandum of understanding with the Shroff Charity Eye Hospital in Delhi, India. Through this relationship, primarily led by the cornea service, we are establishing reciprocal observerships for trainees from both institutions, and collaborations in multi-center research and eye banking.

Local Outreach efforts: In addition to excellent work being done through the free medical clinic and OHES, we aim to increase our community outreach through an initiative titled HawkEYES for All. This initiative, in partnership with Iowa KidsSight, will provide free vision screenings to individuals of all ages including screening for amblyopia, glaucoma, and diabetic retinopathy. The first screening event will take place during the South of 6 Arts & Entertainment family event.

Conclusions: These, among other initiatives, represent our initial efforts in the establishment of an Institute of Global Ophthalmology at the University of Iowa.

Session II – Paper 7

Bilal Ahmed, MD | *Introduction and Implementation of the Iowa Ophthalmology Laser Curriculum*

Primary Supervisors: Jacyln Haugsdal, MD and Pavlina Kemp, MD

Purpose: To provide a structured, simulation-based curriculum to ensure safe skill acquisition for beginning residents learning laser procedures in ophthalmology.

Methods: The PGY-1 residents will participate in four sessions throughout the course of the year to learn each respective laser procedure. Following an instructional lecture, the residents will proceed to practice the techniques discussed on a specific model eye using the laser equipment in the department. These skills based sessions will be performed with direct supervision from a faculty member with expertise in the laser procedure being simulated. A pre-course and post-course assessment will be completed to evaluate competency with each learner. A program evaluation survey will also be completed at the conclusion of each course to assess the degree of confidence in performing the procedure for each learner.

Results: An initial session with YAG capsulotomy was performed in the Fall of 2023. Preliminary survey-based data showed that a majority of trainees had improved confidence in performing a YAG capsulotomy and in identifying the indications of the procedure following the session compared to before the session. In addition, a majority of trainees had improved confidence in recognizing the appropriate energy usage for the procedure and in providing the appropriate post-procedure management following the session compared to before the session. Trainees indicated that following this exercise, they are mostly worried about complications and effectively performing the procedure on patients. Procedural settings and practice of technique were the most useful skills acquired from this simulation session according to survey results. The mean score on the pre-course assessment was 48%. The mean score on the post-course assessment was 88%.

Conclusions: Beginner residents acquire procedural competence and confidence with the use of simulation based curriculum for learning office-based laser procedures.

Session II – Paper 8

Sean Rodriguez, MD | *Operation HawkEyeSight: Two Year Results*

Primary Supervisor: Andrew Pouw, MD; Thomas Oetting, MD, MSc; Ian Han, MD

Co-authors: Zachary Mortensen, Arnulfo Garza, Joanna Silverman, Cheryl Wang, Cy Lewis, Tina Hendricks, Patrick Donegan, Samuel Tadros, Brandon Baksh

Purpose: The Free Medical and Dental Clinic (FMC) has served the local Iowa City community for over 50 years and provides access to care for a largely uninsured and low-income population (>70% below federal poverty level). The Ophthalmology Department has been awarded two health disparities grants with the purpose of creating mechanisms for providing free laser and cataract surgery treatments to the uninsured ophthalmology patients at the FMC.

Methods:

Aim 1: Establish sustainable mechanisms to provide free laser and cataract surgery treatment for selected patients. The demographic information for these patients were tracked along with exam findings, number of treatments received, and visual and surgical outcomes. Patients had option to report their annual household income.

Aim 2: Iteratively improve the economic sustainability of operational costs for free laser and surgery program. Opportunities for cost-effective optimization were identified for each consecutive free surgery day. Additionally, a university-sponsored philanthropic funding pathway was established to create an ongoing funding source. The costs to the grant over time and the donations over time were tracked. Cost analysis was performed to estimate total cost savings to patients.

Results: During the period of February 2022 – March 2024, Operation HawkEyeSight (free surgery and laser program) hosted 20 clinics and 3 surgery days (next surgery day on 5/18/24). There have been approximately 300 unique patient clinic visits. 802 fundus photos and OCTs were obtained with the Maestro2. 31 panretinal photocoagulation were performed. 13 free cataract surgeries were performed. The most recent cataract surgery day (Fall 2023) cost the grant approximately $547.98 per surgery, with $0 cost to patients over this time. Estimated total cost-savings in a subanalysis of 17 patients via these programs was $126,140. This is a cost-savings of about $7,883 per patient (4 of 17 reported annual household income <$10,000).

Conclusions: Mechanisms were established to provide free laser and surgery treatments to uninsured patients at the FMC. The free laser program has minimal remaining current and future barriers to continue in perpetuity. There are surmountable but significant current and future challenges to ensure the longevity of the free cataract surgery program.

Session II – Paper 9

Margaret Strampe, MD | *Quality of Life Improves After Strabismus Surgery*

Primary Supervisor: Alina Dumitrescu, MD

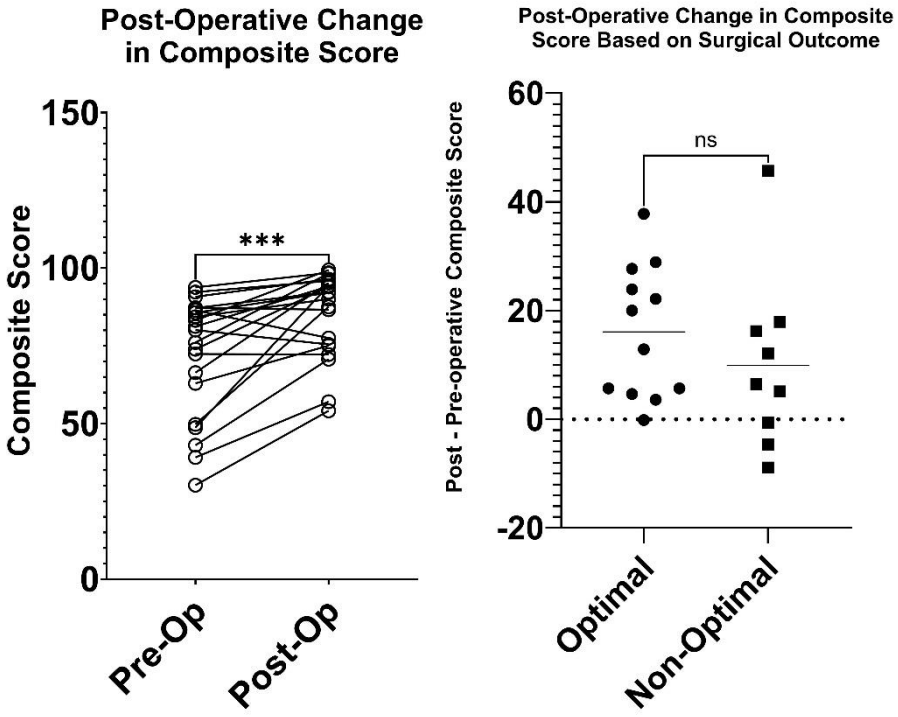
Co-authors: Kristin Davis; Maddy Kroeger; Andrew Solsrud; Joel VandeLune

Purpose: Strabismus affects about 4% of adults. It hinders quality of vision and depth perception while creating a visible physical disability. Vision accounts for about 80% of humans' senses and eye contact is essential for social interaction. This study is measuring the physical and emotional impact of strabismus on adults.

Methods: The National Eye Institute's Visual Function Questionnaire-25 (VFQ-25) was given to adults with strabismus and repeated if they underwent corrective surgery. The surveys were scored into 12 subscales assessing quality of life and vision.

Results: 105 patients were enrolled in this study. 20 underwent strabismus surgery. All patients showed decreased VFQ-25 composite scores compared to a reference group ($p<0.001$). The most impacted score was mental health ($p<0.001$). For patients who underwent surgery, there was a significant increase in quality of life and vision scores ($p<0.001$). There was no significant difference in post-operative improvement of composite scores between patients with optimal and non-optimal surgical outcomes ($p=0.2394$).

Conclusions: This study shows the impact of strabismus on visual functioning and quality of life, as well as the benefits of strabismus surgery, which should not be considered cosmetic, as it restores appearance, binocularity, and improves quality of life.



Session II – Paper 10

Giulia Steuernagel Del Valle, MD | *Flash Visual Evoked Potential in Pediatric Inherited Eye Disease*

Primary Supervisor: Arlene Drack, MD

Co-authors: Wanda Pfeifer, MME, CO, COMT; Rose McGlaufin, MD

Purpose: To evaluate the correlation of Flash Visual Evoked Potentials (FVEP) with Full Field Electroretinogram (ERG), Best-corrected visual acuity (BCVA) and Goldmann Visual Field (GVF) in pediatric patients with Inherited Eye Disease.

Methods: Retrospective chart review of patients who underwent both ERG and FVEP from 3/1/2010 to 12/1/2023 was performed. Patients with poor cooperation during testing and patients older than 18 years old were excluded. Collected data included clinical and molecular diagnoses, amplitudes, and latencies from ERG and FVEP, distance BCVA, and GVF.

Results: Test results from 118 patients obtained in 194 different visits were included. Age ranged from 2 months to 18 years (Mean 7.06 ±SD 5.44 years). Among the patients, 43% were female (n=51); 40% had progressive disease (n=47), and 60% had a definitive molecular diagnosis (n=70). A moderate to strong correlation was found between FVEP P120 amplitude and LogMAR visual acuity ($r= -0.41$, $p < 0.001$). When comparing FVEP P120 amplitudes to ERG waveform amplitudes, the strongest correlation was found with the 3.0 Light Adapted B wave ($R=0.33$, $p<0.0001$). A moderate correlation was observed with the 3.0 Light Adapted A wave ($R=0.31$, $p<0.0001$) and the 30Hz Flicker ($R=0.31$, $p<0.0001$). Dark Adapted ERG 0.01 B wave ($r=0.25$, $p<0.01$) and 3.0 A wave ($R=0.19$, $p<0.01$) exhibited a low correlation with the FVEP P120 amplitude, whereas the Dark Adapted 3.0 B wave showed a weak to moderate correlation ($R=0.29$, $p<0.01$). On GVF, patients with central scotoma presented significantly lower FVEP amplitudes compared to those without central scotoma, despite the area of visual field (MD -11.01 95% CI [-16.85; -5.17]; p=0003). FVEP amplitudes were significantly higher in patients perceiving smaller GVF targets (I1e) compared to only larger targets (III4e, V4e) ($p < 0.0001$).

Conclusions: FVEP correlates with visual acuity, GVF, and light-adapted ERG, suggesting its quantitative value for assessing vision. FVEP can be a viable alternative for monitoring vision and retinal degeneration in young children.

Session III – Paper 11

Rupin Parikh, MD | *Preliminary Outcomes Using a Novel Protocol for Management of Burn Patients at Risk of Orbital Compartment Syndrome*

Co-authors: Chau Pham, MD; Julia Fleecs, BS; Jamie Keen, MD; Keith Carter, MD; Erin Shriver, MD

Purpose: Burn injuries can lead to devastating ocular and periocular sequelae that compromise vision. One severe and acute complication is orbital compartment syndrome (OCS). To date, there is no gold-standard protocol for management of these patients upon their presentation to the hospital. A protocol for the management of burn inpatients was developed and risk factors were identified in a previous investigation at the study institution. This study is the first retrospective review assessing the outcomes of this novel protocol used in the management of burn patients at risk for orbital compartment syndrome.

Methods: A retrospective review was performed at the study institution to evaluate burn patients in which ophthalmology was consulted. Patients were excluded if they had a known history of glaucoma or if they had other conditions affecting the orbital pressure such as a traumatic retrobulbar hemorrhage. The following data were collected: age, gender, percent of total body surface area (%TBSA) involved, time of burn injury, use of vasopressors or albumin, type of intravenous fluids used, initial and final visual acuity, presence of chemosis, if brimonidine was initiated at presentation, frequency of intraocular pressure (IOP) checks, IOP measurements and number of hours each measurement was made after the injury, if surgical intervention was performed (canthotomy, lower cantholysis, upper cantholysis, lower septolysis, upper septolysis, lower eyelid split, and upper eyelid split), time to surgical intervention after the injury, and whether subsequent repair of the cantholysis was required.

Results: Twelve patients and 24 eyes meeting inclusion criteria were identified. The mean %TBSA in patients that underwent surgical intervention was 68.8%, compared to 12.8% in the non-surgical group. The average IOP that initiated surgical intervention was 45.8 mmHg. Surgical intervention was performed by ophthalmology-trained physicians bilaterally on 6 patients (50%). The average time from the initial injury to ophthalmology consultation was 9.3 hours, and when performed, the average time to surgical intervention was 5.4 hours later. A canthotomy and inferior cantholysis alone was sufficient in reducing the IOP in 4 eyes, while 2 eyes also required a superior cantholysis. An additional septolysis and/or eyelid split were required in 6 eyes. The average one-hour post-surgical intervention IOP was 23.1 mmHg. Brimonidine was started on two patients that did not undergo surgical intervention. Four of the 6 patients requiring surgical intervention had initial IOPs < 30 mmHg, and average time to IOP spike requiring surgical intervention was 10.3 hours. Two of the 6 surgical intervention patients expired from their injuries, and 3 required subsequent eyelid repair.

Conclusions: This study further supports close initial monitoring for OCS during the acute phase of presentation in burn trauma patients. Examination frequency can be adjusted based on the presence of risk factors such as %TBSA, use of vasopressors or albumin, or presence of chemosis.

Session III – Paper 12

Lindsay Chun, MD | *Quantitative Assessment of Eyelid Dynamics and Variability for Differentiating Causes of Ptosis*

Primary Supervisor: Randy Kardon MD, PhD

Co-authors: Pieter Poolman, PhD; Julie Nellis, BSN; Erin Shriver, MD

Purpose: We developed and tested a clinical video-based system for recording and automatically tracking eyelid dynamics and variability to discover features that differentiate causes of ptosis and response to treatment. Currently, methods are lacking for use in a clinical setting that automatically tracks the border of the upper and lower eyelids.

Methods: A four camera video system was developed using 2-megapixel miniature infrared video cameras surrounding an iPad. Spontaneous and light-induced eyelid and pupil movements were recorded at 57Hz from both eyes simultaneously for 3 minutes. The multicamera system enabled a 3D modeling of the eye and eyelids. Recorded video frames were used to train a model to automatically track the upper and lower borders of the eyelids in each recorded video frame. In this pilot study, we tested patient examples of different causes of ptosis; myasthenia gravis, Horner's syndrome, incomplete 3rd nerve palsy and normal patients. The dynamics of eyelid closure, eyelid opening, and variability of eyelid fissure, as well as variability of inter-eye fissure asymmetry were quantified.

Results: In myasthenia, graphs of inter-eye fissure asymmetry revealed small, but significant variations over time, often reversing sign upon eyelid opening following a blink, that were not apparent on viewing of the video (subclinical). Lag of eyelid opening could be observed in Horner syndrome, due to Mueller's muscle involvement.

Conclusions: Quantitative video-based analysis of eyelid fissure variability and dynamics of eyelid movements in a clinical setting provide a new, accessible foundation for categorizing and differentiating different causes of ptosis and response to treatment.

Matthew Hunt, MD | *Machine-Learning Exploration and Classification of Automated Pupillary Data*

Primary Supervisors: Edward Linton, MD; Randy Kardon, MD, PhD
Co-author: Peiter Poolman

Purpose: Automated pupillometry can provide an objective measurement of afferent visual function that is fast, repeatable, and will become portable, enabling new avenues for longitudinal monitoring of optic nerve and retinal disorders. However, conventional analysis of the pupillometry waveform suffers from artifact and relies on fixed, human-designed features (e.g. maximal constriction under a single stimulus intensity). Machine-learning (ML) analysis of these waveforms may better identify clinically significant changes and even uncover hidden connections between pupillary dynamics and disease.
Methods: We developed a 20-second test to interrogate the pupil light reflex using Neuroptics DP-2000. Using training data from 272 patients with several categories of optic neuropathy, we averaged the right and left pupil diameter at each timepoint and reduced the dimensions of the pupil-diameter-time-series data 60-fold using unsupervised machine learning. Principal component analysis (PCA), a linear unsupervised ML algorithm, was compared to a deep-learning variational autoencoder (VAE). The dimension-reduced data could be visualized on a 2D scatter plot, and the separation of right from left unilateral optic neuropathies was visualized for both methods.
Results: Compressed data was distributed smoothly in our 2D latent space with natural separation between right and left optic neuropathies. A linear classifier applied to latent space distinguished between right and left optic neuropathies with 84% accuracy for both PCA and the VAE, while a traditional hand-engineered approach gave only 77% accuracy. The VAE gave much better waveform reconstructions (>4x more accurate by mean-squared error). Higher intensity stimuli tended to better distinguish disease laterality.
Conclusions: These unsupervised methods transformed raw, noisy pupil-diameter data into a continuous and visualizable disease representation. Our novel visualization tool opens the “black box” of deep learning by providing insight into how the VAE compresses data. The VAE could reduce artifacts by preserving waveform dynamics and may capture longitudinal disease progression.

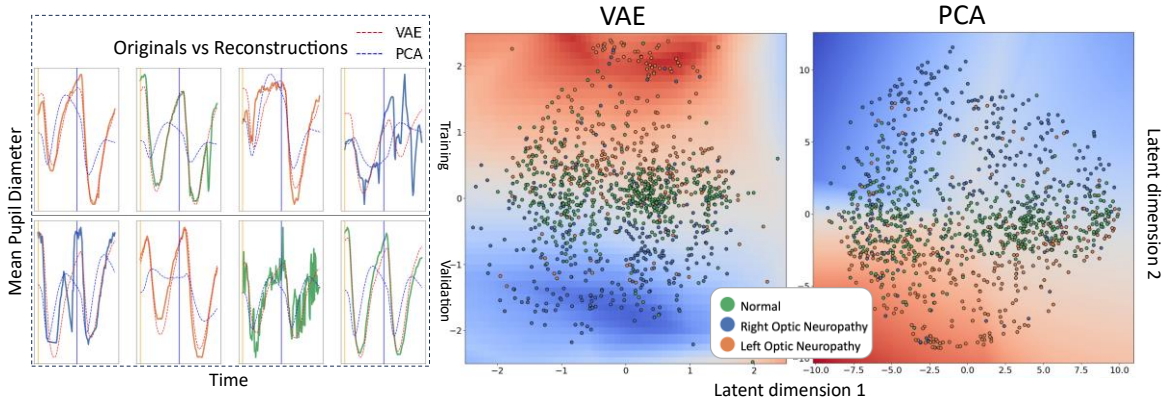


Figure 1: Pupillometry waveforms (solid lines) color-coded according to right (blue) vs left optic neuropathy (orange) vs normal (green). Reconstructions from VAE vs PCA shown as red and blue dashed lines. VAE vs PCA 2D embeddings shown for comparison.

Session III – Paper 14

Judith Brody, MD | *Retinal Nerve Fiber Layer and its Spatial Pattern in Typical and Atypical Optic Neuritis*

Primary Supervisors: Randy Kardon MD, PhD; Edward Linton MD

Co-authors: Jui-Kai (Ray) Wang PhD; Brett Johnson, Mark Kupersmith MD, Mona Garvitn PhD, Riley Filister, David Szanto, Joseph Branco

Purpose: Causes of optic neuritis (ON) can be difficult to distinguish at presentation before serologic testing results are known. We applied a novel deep-learning variational autoencoder (VAE) to determine whether OCT thickness maps can distinguish between typical (multiple sclerosis; MS) and atypical (myelin oligodendrocyte glycoprotein antibody-associated disease; MOGAD vs. neuromyelitis optica spectrum disorder; NMOSD) ON at presentation and at later time points.

Methods: A total of 797 OCT scans from 97 healthy subjects and 2036 scans from 147 ON subjects were used to train a VAE model, resulting in 2 variables, d1 and d2, which depict a continuum of spatial patterns of retinal nerve fiber layer (RNFL) in a montage map with axes of d1 (x-direction) and d2 (y-direction). In the test set, OCT scans of the affected and unaffected eyes (147 MS, 26 MOGAD, and 26 NMOSD subjects) at the acute and chronic stages were identified by their location on the montage map. Average RNFL thickness values in the acute and chronic stages were also compared between the groups.

Results: Acute ON in MOGAD was associated with greater disc edema at presentation [184±81um] than NMOSD [124±46um (p=0.01)] or MS [99.1±24um (p=<0.0001)]. Although significant differences were found, there was still considerable overlap between the spatial pattern of RNFL thickness among different causes of ON. NMOSD cases had lower RNFL thickness [61.2±18um] after three months vs MOGAD [73.4±14um p<0.0001] or MS [76.6±20.4, p<0.0001]. Our RNFL VAE map successfully depicted the RNFL spatial patterns in each patient and their change from acute to chronic stages.

Conclusions: The VAE model allows us to better characterize the differences in RNFL patterns between MS, MOGAD and NMOSD and relate these patterns to visual function over time.

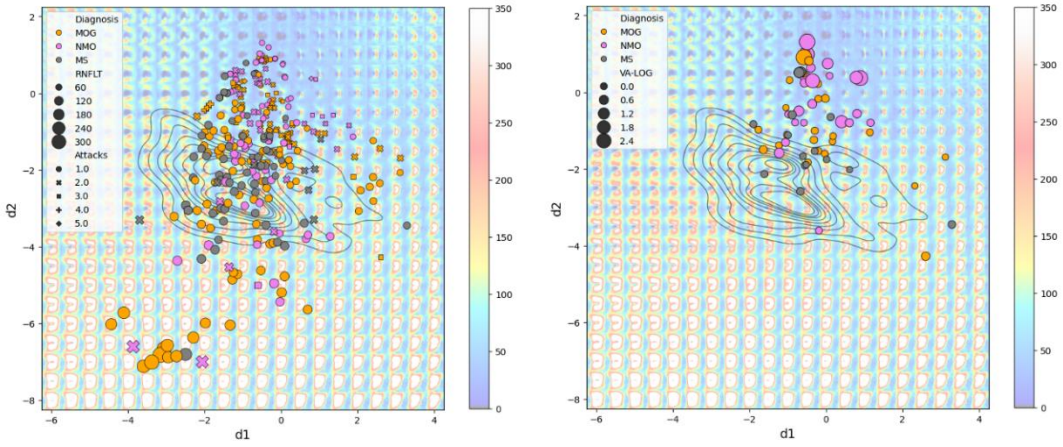


Figure 1. Montage maps of typical and atypical optic neuritis. (A) RNFL thickness; (B) Final visual acuity

Session III – Paper 15

Samuel Tadros, MD | *A Light-Emitting Diode Anomaloscope for Assessing Color Vision Abnormalities*

Primary Supervisor: Edwin Stone, MD, PhD

Co-authors: Adam DeLuca, PhD; Todd Scheetz, PhD

Purpose: Assessment of color vision abnormalities has been an area of active research for well over 100 years. Currently, there are several modalities for testing color vision, including pseudoisochromatic plates and chip arrangement tests. The gold standard for characterizing congenital color blindness is the anomaloscope, an instrument that asks a subject to match a mixture of two monochromatic lights of different wavelength with a third monochromatic light of intermediate wavelength. This test has limited utility clinically given the cost of commercial instruments and the expertise required to operate them. However, since light emitting diodes emit fairly monochromatic light, it may be possible to use them to construct a practical, inexpensive anomaloscope that can provide much of the clinical information that conventional optical instruments provide.

Methods: A prototype anomaloscope has been constructed with a red-green bi-color LED (630nm, 565nm) flanked by two yellow LEDs (591nm) controlled by an iPad-based application that presents a series of potential matches to the subject, scores the results, and generates a report that can be uploaded to an electronic medical record.

Results: This device was tested on normal individuals and those with confirmed hereditary dyschromatopsia identified by HRR color plates and D15 arrangement tests. Protanomalous and deuteranomalous individuals have been assessed. Representative results from normal and protanomalous individuals are shown in Figure 1.

Conclusions: This digital anomaloscope represents a potentially promising method to assess patients with hereditary forms of color blindness. Further work is needed to demonstrate the test's sensitivity and specificity for different forms of X-linked dyschromatopsias, as well as other inherited conditions like blue cone monochromacy and achromatopsia.

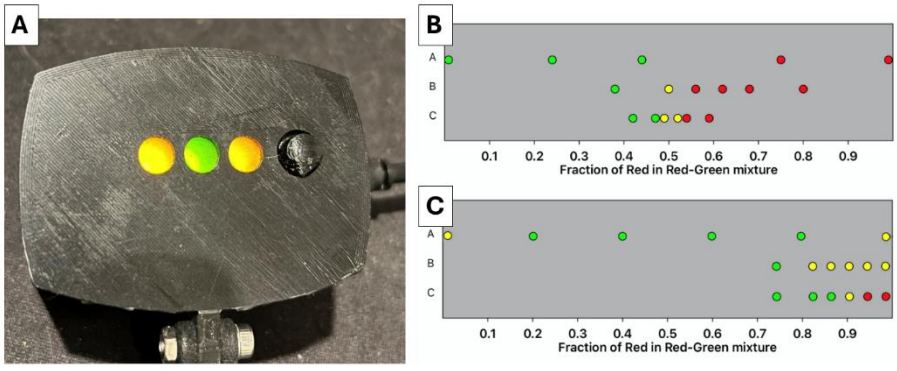


Figure 1: Panel A shows photograph of LED anomaloscope with bi-color LED in the middle. Panel B shows results from a normal subject. Panel C shows results from a protanomalous subject.

Session IV – Paper 16

Arnulfo Garza Reyes, MD | *Evaluation of Pigmentation Artifact in Ultra-Widefield Imaging of Ocular Tumors*

Primary Supervisor: Elaine Binkley, MD

Co-authors: Culver H. Boldt, MD, Connie Hinz, CCRC, COT, Samuel Tadros, MD

Purpose: Ultra-widefield (UWF) imaging systems are an essential tool to diagnose, monitor, and determine treatment for a multitude of conditions including ocular tumors. While these imaging systems are helpful tools, the clinical exam and determination of the true color of a lesion is essential to constructing an appropriate differential diagnosis and arriving at the correct diagnosis. While UWF systems have allowed clinicians to capture more peripheral lesions, the pigmentation artifact with these cameras compared to the gold standard true color Topcon images (Topcon Healthcare, Oakland NJ) is an important limitation that has not been well described in the literature. This is of particular relevance given the increasing role of artificial intelligence-based algorithms using ophthalmic imaging for diagnostics. In particular, one of the most commonly used cameras for imaging ocular neoplasms is the Clarus (Carl Zeiss Meditech Inc., Dublin, CA) due to its ability to obtain a more "true-color" image with up to 200° field of view. However, there is often significant pigmentation artifact that can change the differential diagnosis. In this study, we describe the pigmentation artifact of choroidal lesions imaged with the Clarus camera.

Methods: This was a single-center, IRB-approved, retrospective study reviewing a consecutive series of patients referred for ocular oncology evaluation over a five-year period. Patients who had imaging on both the Topcon and Clarus cameras at different points in time were identified. The clinical diagnosis was recorded for each patient. Imaging for each patient was reviewed.

Results: 53 patients referred for ocular tumor evaluation who had imaging on both the Topcon and Clarus cameras were identified. The two most common diagnoses in the cohort were choroidal nevus (45%) and choroidal melanoma (35%.) Each of the patients' images were reviewed by one of ocular oncologists comparing the pigmentation appearance on the Clarus to the Topcon images as well as the clinical exam description.

Conclusions: Ocular oncologists and general ophthalmologists are highly encouraged to confirm the color of ocular lesions clinically given the pigmentation artifact present in commonly used systems like the Clarus. Failure to do so can result in misdiagnosis and inappropriate timing of referrals.

Session IV – Paper 17

Rupak Bhuyan, MD | *Choroidal Metastasis in the Era of Targeted Systemic Therapy*

Primary Supervisor: Elaine Binkley, MD

Co-authors: Moses Evbuomwan, MD; Uwajachukwumma Uzomah, MD, MPH; Carryn Anderson, MD; H Culver Boldt, MD

Purpose: Intraocular metastases are the most common intraocular malignancies in adults. Radiation therapy has historically been the gold standard for controlling these tumors. Recently, successful treatment has been reported with systemic targeted therapies. Given the heterogeneity of these tumors and their treatment, there has not been a randomized controlled study to determine whether systemic targeted therapy could be used as adjuvant treatment or as a first-line replacement for radiation therapy.

Methods: This is a single-center retrospective review of patients with choroidal metastases who presented to the department of ophthalmology at the University of Iowa from 2018 to 2023. The University of Iowa Institutional Review Board granted an IRB exemption. The patient age at diagnosis, primary malignancy, treatment modality, radiation dosimetry, tumor response, final visual acuity, and mortality data were recorded for each patient.

Results: Twenty-six patients were identified who met inclusion criteria. Mean age at the time of choroidal metastasis diagnosis was 59 years. Fifty percent of patients were female and 50% were male. Lung (34.6%) was the most frequent primary tumor followed by breast (30.8%), clear cell renal cell (11.5%), esophageal (11.5%), and other tumor types (11.5%). Half of the patients received a single mode of treatment: hormone therapy (19.2%), chemotherapy (15.4%), immunotherapy (11.5%), and targeted biologic therapy (3.9%). The remaining half received multiple types of treatment. Fifteen patients received radiation. Twelve of these exhibited involution of ocular lesions; the remaining 3 died before follow-up. Eleven had good final visual acuity (≥20/40). Of the 11 non-radiated patients, 4 experienced involution, 2 worsened, and 5 outcomes were unknown (including 4 deaths). Sixteen patients died within 3 years of diagnosis.

Conclusions: Overall, patients with choroidal metastases who received radiation therapy generally exhibited good ocular tumor response and maintained good visual acuity (≥20/40). Given the good visual acuity outcomes and typically short survival time following diagnosis of choroidal metastasis, most patients may not live long enough to develop radiation retinopathy as a side effect of radiation therapy. Therapy for choroidal metastasis should be on a case-by-case basis with a low threshold for radiation given the overall good visual outcomes.

Session IV – Paper 18

Farzad Jamshidi, MD, PhD | *Belzutifan for the Treatment of Retinal Hemangioblastomas in Von Hippel-Lindau*

Primary Supervisor: Elaine Binkley, MD

Co-authors: Lola Lozano BS, Budd Tucker PhD, Jean Andorf BA, Elliott Sohn MD, Edwin Stone MD PhD, Andrew Groves MD, Yousef Zakharia MD, H. Culver Boldt MD

Purpose: The systemic HIF-2 alpha inhibitor, belzutifan, has been approved for use in patients with Von Hippel-Lindau (VHL)-associated renal cell carcinoma, central nervous system hemangioblastomas, and pancreatic neuro-endocrine tumors. The purpose of this study was to examine the efficacy of this medication in the treatment of challenging retinal hemangioblastomas (RH) in VHL.

Methods: We conducted a retrospective review of patients with VHL-associated RH who were treated with systemic belzutifan. Patient age, gender, genotype, presence of systemic tumors, indication for the drug, initial dose, adjusted dose, side effects, and tumor response were recorded. Two patients were initiated on belzutifan for their ocular disease secondary to challenging and ablative treatment-resistant lesions. The other 5 patients were receiving systemic treatment for other VHL tumors but concomitantly had ocular involvement. We conducted a retrospective review of patients with VHL-associated RH who were treated with systemic belzutifan. Patient age, gender, genotype, presence of systemic tumors, indication for the drug, initial dose, adjusted dose, side effects, and tumor response were recorded. Two patients were initiated on belzutifan for their ocular disease secondary to challenging and ablative treatment-resistant lesions. The other 5 patients were receiving systemic treatment for other VHL tumors but concomitantly had ocular involvement.

Results: We identified 12 eyes of 7 patients with VHL-associated ocular tumors who were treated with systemic belzutifan. 5 eyes of 3 patients had progressing ocular tumors when belzutifan was started. Of the 7 total patients, 2 were treated for renal cell carcinoma, 2 for CNS hemangioblastomas, 2 for RH, and one for pancreatic neuro-endocrine tumor. The dose was reduced in all but one patient due to side effects. The ocular tumors were controlled in all patients with average follow up of 13 months (range 4-24 months).

Conclusions: Systemic belzutifan shows great promise for controlling challenging RH and preventing vision loss in these patients. Further work needs to address the optimal dose, long-term efficacy, and tolerability of the drug in a larger cohort of patients with ocular tumors.

Session IV – Paper 19

Kyle Green, MD | *Drusen Regression after Macula-involving Rhegmatogenous Retinal Detachment Repair*

Primary Supervisors: Timothy Boyce MD, Jonathan Russell, MD, PhD

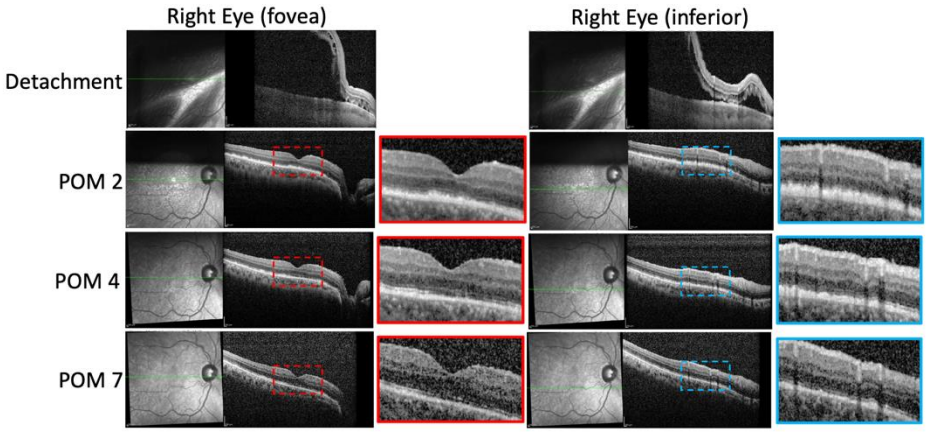
Co-authors: Taariq Mohammed, MD, Jonathan Russell, MD, PhD, Timothy Boyce, MD

Purpose: To investigate the effect of macula-involving rhegmatogenous retinal detachment repair on drusen regression.

Methods: A retrospective review of patients with drusen who underwent macula-involving rhegmatogenous retinal detachment repair was performed. Optical coherence tomography and fundus photographs were reviewed when available for patients before retinal detachment, at the time of retinal detachment, and at subsequent post-operative follow-up visits. By consensus, each case was grouped into one of the following categories: (1) predominant regression of drusen overtime (2) predominant persistence of drusen overtime, or (3) mixed. Mixed cases demonstrated some combination of drusen regression and persistence, or other changes in drusen characteristics that could not be reasonably placed in either category.

Results: 14 eyes with drusen that underwent macula-involving retinal detachment repair were identified. Regression of drusen was seen in 6 eyes (43%). Persistence of drusen was seen in 5 eyes (36%). 3 eyes were categorized as mixed (21%). In one case with drusen regression and long-term follow-up, there was progression to atrophy.

Conclusions: The course of drusen following repair of macula-involving rhegmatogenous retinal detachments is highly variable, ranging from marked regression to no appreciable change. The precise mechanism for drusen regression, and the long-term pathophysiologic consequences of regression, are not known.



50-year-old female with drusen regression over a 7-month period following repair of a macula-involving rhegmatogenous retinal detachment with pars plana vitrectomy.

Session IV – Paper 20

Taariq Mohammed, MD | *Microvascular Changes Underlying Cystoid Macular Edema in Retinitis Pigmentosa*

Primary Supervisor: Ian Han, MD

Co-authors: Kyle Green, MD; Brice Critser BS, CRA; Edwin Stone, MD, PhD

Purpose: The epidemiology and pathophysiology of cystoid macula edema (CME) secondary to retinitis pigmentosa (RP) is unknown. Swept-source optical coherence tomography angiography (SSOCTA) provides unprecedented ability to visualize the retinal and choroidal vasculature, and has shown a relationship between deep capillary plexus (DCP) loss and the development of cystoid macular edema in diseases like diabetic retinopathy and retinal vein occlusion. The purpose of this study is to explore the relationship between the DCP loss, ellipsoid zone (EZ) loss, genotype, and the development of CME in RP.

Methods: Consecutive patients seen at a single tertiary care with molecularly confirmed RP from 2017 to 2023 who obtained SSOCTA (Zeiss Plex Elite) imaging will be included. Patient characteristics recorded will include diagnosis, genotype, and presenting and final visual acuity and genotype. The SSOCTA images will be manually segmented to identify CME, DCP loss, and EZ loss, and these areas will be correlated. For this abstract, the subset of patients with *USH2A*-associated non-syndromic RP were included.

Results: Of the 190 patients with available SSOCTA imaging, with 18 eyes of 9 patients with non-syndromic *USH2A*-associated RP were evaluated. Of these, CME was seen in 6 out of 18 eyes (33.3%). Median visual acuity at final follow up was 20/40 in both groups. 4 eyes of 2 patients were treated with oral Diamox with resolution of CME. Figure 1 shows the relationship of CME to EZ and DCP loss in an exemplar patient.

Conclusions: CME is a common complication of RP that may be associated with particular genotypes, and is likely pathophysiologically related to DCP and EZ loss. Improved understanding of CME in RP can improve understanding of retinal fluid clearance as it relates to a range of retinal vascular diseases.

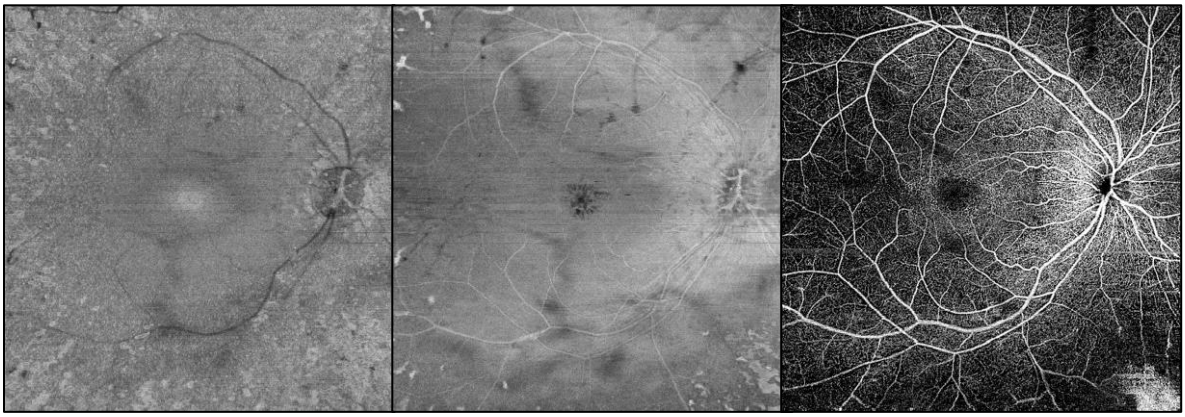


Figure 1. SSOCTA structural slabs showing the ellipsoid zone and cystoid macular edema (left and middle respectively), and the angiography slab of the deep capillary plexus showing qualitative capillary loss paracentrally (right).