RESIDENT / FELLOW
RESEARCH DAY

Department of Ophthalmology
and Visual Sciences

~

Roy J. and Lucille A. Carver
College of Medicine

University of Iowa Hospitals & Clinics

Iowa City, Iowa

Braley Auditorium, 01136 Lower Level, Pomerantz Family Pavilion

Friday, May 17, 2013, 8:00 AM-4:00 PM

UNIVERSITY OF IOWA HEALTH CARE

Department of Ophthalmology and Visual Sciences

RESIDENT/FELLOW RESEARCH DAY - 2013

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RESIDENT/FELLOW RESEARCH DAY - 2013

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Rachel K. Sobel, M.D.

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RESIDENT/FELLOW RESEARCH DAY - 2013

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Elizabeth H. Gauger, M.D.
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Justin M. Risma, M.D.
Matthew C. Weed, M.D.

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Jonathan L. Hager, M.D.
C. Blake Perry, M.D.
Bradley A. Sacher, M.D.
Jesse M. Vislisel, M.D.
Jeffrey D. Welder, M.D.

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Amy M. Troll, B.A., First Year

GUEST FACULTY

4th Annual Distinguished Ophthalmic Educator

Randall J. Olson, M.D.

Dr. Randall Olson is the Chairman and John A. Moran Presidential Chair of Ophthalmology at the University of Utah School of Medicine. He is also the Director and Chief Executive Officer (CEO) of the John A. Moran Eye Center.

A native of California, Dr. Olson received his baccalaureate and medical degrees from the University of Utah. He subsequently completed an ophthalmology residency at the Jules Stein Eye Institute at the University of California-Las Angeles and cornea fellowships at the University of Florida and Louisiana State University (LSU).

Dr. Olson has held several prestigious academic and administrative appointments since the completion of his ophthalmic training. In 1977, he was appointed as an Assistant Professor of Ophthalmology at the LSU Eye Center. In 1979, he was appointed at an Associate Professor at the University of Utah and quickly promoted to Full Professor at the same institution in 1982. From 1984 to 1986, he served as the Medical Director at the King Khaled Eye Specialist Hospital in Riyadh, Saudi Arabia, after which he returned to the University of Utah and assumed his current position at the Chair of the Department of Ophthalmology. In 1997, he became the Director of the Moran Eye Center whose opening was primarily fueled by his vision and fund raising efforts. In 2006, he was appointed as the CEO of this now internationally recognized center of ophthalmic excellence.

Dr. Olson has received many awards and honors for his contributions to patient care and ophthalmic education. His clinical expertise in corneal and cataract surgery has been recognized with multiple “Best Doctor” and “Leading Physicians of the World” citations. He has participated in hundreds of professional meetings, seminars, and courses and has not infrequently won “Best Speaker” and “Best Paper/Poster” awards. The American Academy of Ophthalmology has recognized his teaching contributions with the Honor Award and Senior Honor Award.

Despite his heavy clinical care, administrative, and teaching responsibilities, Dr. Olson has made major contributions to academic ophthalmology. He has been an Associate Editor of 3 journals (including the Journal of Cataract and Refractive Surgery) and on the Editorial Board of 17 journals (including the Archives of Ophthalmology, American Journal of Ophthalmology, and Refractive Surgery). He currently has 7 active federal and private industry sponsored grants and has previously received an additional 41 funded grants and contracts. He is the author or co-author of numerous landmark scientific publications including over 230 peer-reviewed journal articles and over 65 book chapters.

5th Annual Distinguished Alumni Society Representative

Jeffrey A. Nerad, M.D.

Dr. Jeffrey Nerad is a Professor of Ophthalmology at the University of Cincinnati School of Medicine and the Director of the Oculoplastics and Orbit Division at the Cincinnati Eye Institute.

A native of California, Dr. Nerad received his BA degree from the University of California-Los Angeles. He received his medical degree and his ophthalmology residency training at St Louis University School of Medicine. He completed oculoplastics fellowships at the prestigious Moorfields Eye Hospital and University of Iowa Hospitals and Clinics (UIHC). In 1989, he was inducted as a fellow into the American Society of Ophthalmic Plastic and Reconstructive Surgery (ASOPRS).

Dr. Nerad has held several prestigious academic and administrative appointments since the completion of his ophthalmic training. In 1985, he was appointed as an Assistant Professor of Ophthalmology at UIHC. He was quickly promoted to Associate Professor in 1989 and Full Professor in 1993 at the same institution where he later was installed as the Fuerste Professor of Ophthalmology. From 1985 to 1987, he served as the Chief of Ophthalmology at the Veterans Administration Medical Center. In 1986, he was appointed as the Chief of the Oculoplastics and Orbital Division at UIHC, a position he held until his departure to the Cincinnati Eye Institute in 2009.

Dr. Nerad has received many awards and honors for his contributions to patient care and ophthalmic education. His clinical expertise in oculoplastics and orbital surgery has been recognized with multiple "Best Doctor" citations. He has participated in hundreds of professional meetings, seminars, and courses. The American Academy of Ophthalmology has recognized his teaching contributions with the Honor Award, Senior Honor Award, and Secretariat Award.

Despite his heavy clinical care, administrative, and teaching responsibilities, Dr. Nerad has made major contributions to academic ophthalmology. He is the author or co-author of over 90 stellar peer-reviewed journal articles and 30 book chapters. His landmark textbook, *The Requisites of Ophthalmology: Oculoplastics,* is widely recognized as one of the greatest books ever written on its subject matter.

4th Annual Leinfelder Society Alumni Representative

Edward H. Hu, M.D., Ph.D.

Dr. Edward Hu is a cataract and refractive surgeon with Eye Surgeons Associates in the Bettendorf, Iowa.

A native of Maryland, Dr. Hu received his BS degree from the Massachusetts Institute of Technology, after which he obtained an MD/PhD degree from New York University School of Medicine. The topic of his PhD dissertation was, "The role of neuronal coupling in the correlated spike activity of alpha ganglion cells of the rabbit retina." In June 2008, he completed his ophthalmology residency training at the University of Iowa Hospitals and Clinics.

Despite his relative youth and short career, Dr. Hu has been the recipient of many prestigious awards and prizes. As a medical student, he received an ARVO/NEI student travel award in 1999 and a Research to Prevent Blindness research fellowship in 2002. As a resident, he was invited to the inaugural residency retreat of the Heed Ophthalmic Foundation in 2006 and received the prestigious Leinfelder Award in 2007 for the best resident research project on "The role of contact lens solution types as a substrate in the viability of *Fusarium* species: potential implications in contact lens related fungal keratitis."

Dr. Hu is the author or co-author of 15 scientific publications, including 8 peer-reviewed journal articles.

The University of Iowa
Department of Ophthalmology and Visual Sciences
Resident and Fellow Research Program
would like to recognize

The William C. and Dorotha Gaedke Charitable Trust

for their continued support of
resident and fellow research

Research at The University of Iowa Department of Ophthalmology and Visual Sciences is supported in part by an unrestricted grant from
Research to Prevent Blindness

RESIDENT / FELLOW RESEARCH DAY

May 17, 2013

Department of Ophthalmology
and Visual Sciences

University of Iowa
Roy J. and Lucille A. Carver
College of Medicine

University of Iowa
Hospitals and Clinics

Iowa City, Iowa

OPHTHALMOLOGY RESIDENT/FELLOW RESEARCH DAY
SCHEDULE OF EVENTS

Friday, May 17, 2013, 8:00 AM - 4:00 PM

8:00 Welcome: **Michael D. Wagoner, M.D., Ph.D.**

8:10 – 9:45 **Scientific Papers, Session I**
Braley Auditorium
Moderator: Edward H. Hu, M.D., Ph.D
4th Annual Distinguished Leinfelder Society Representative

8:10 Introduction of Edward H. Hu, M.D., moderator

8:15 **Rachel K. Sobel**, sponsor, Richard C. Allen 1
Systemic associations with nasolacrimal duct obstruction

8:30 **Jonathan L. Hager**, sponsor, Kenneth M. Goins 2
K-Pro I outcomes

8:45 **C. Blake Perry**, sponsor, Richard C. Allen 3
Repair of 50-75% full-thickness lower eyelid defects: The principle of lateral stabilization

9:15 **Bradley A. Sacher**, sponsor, Anna S. Kitzmann 5
Intravenous pentamidine for *Acanthamoeba keratitis*

9:30 **Jesse M. Vislisel**, sponsor, W.L.M. Alward 6
Reversibility of visual field deficits in glaucoma patients

9:45 – 10:15 **Morning Break**

10:15 – 11:00 **Keynote Address**
Braley Auditorium

10:15 Introduction of Randall J. Olson, M.D., Keynote Speaker

10:20 **Randall J. Olson, M.D.,** Keynote Address. "A lesson in pursuit of new understanding *via* clinical research"

11:00 – 12:00 **Scientific Papers, Session II**
Braley Auditorium
Moderator: Randall J. Olson, M.D.
4th Annual Distinguished Ophthalmic Educator

11:00 **Angela R. McAllister**, sponsor, Michael D. Abràmoff 7
Deviation from the optimal branching relationship of retinal vessels in diabetes mellitus

OPHTHALMOLOGY RESIDENT/FELLOW RESEARCH DAY
SCHEDULE OF EVENTS

Friday, May 17, 2013, 8:00 AM - 4:00 PM

11:15 **Elizabeth H. Gauger**, sponsor, Vinit B. Mahajan 8
Combined pars plana vitrectomy and glaucoma drainage implant insertion

11:30 **Jeffrey D. Welder**, sponsor, Mark Greiner 9
Limiting infectious complications in Boston type I keratoprosthesis

11:45 **Justin M. Risma**, sponsor, Young H. Kwon 10
Diaton tonometry in patients with ocular hypertension, glaucoma, and glaucoma drainage devices—A preliminary study for its potential use in keratoprosthesis patients
[Leinfelder Award Winning Paper]

12:00 – 1:15 **Buffet Luncheon**
Melrose Conference Center, 5th Floor, PFP

1:15 – 2:30 **Scientific Papers, Session III**
Braley Auditorium
Moderator: Jeffrey A. Nerad, M.D.
5th Annual Distinguished Ophthalmology Alumni Representative

1:15 Introduction of Jeffrey A. Nerad, MD, Moderator

1:20 **Matthew C. Weed**, sponsor, Michael D. Wagoner 11
Visual loss after contact lens-related *Pseudomonas* keratitis

1:35 **Matthew A. Cunningham**, sponsor, James C. Folk 13
Acute optical coherence tomography changes over involuted choroidal neovascularization in the presumed ocular histoplasmosis syndrome
[Leinfelder Award Winning Paper]

1:50 **Meagan D. Seay**, sponsor, Nasreen A. Syed 14
Iron deposition in ocular tissues of young children: An autopsy series

2:05 **Shandiz Tehrani**, sponsor, Markus H. Kuehn 15
The optic nerve head actin cytoskeleton and its role in glaucoma

2:30 – 2:45 **Afternoon Break**

OPHTHALMOLOGY RESIDENT/FELLOW RESEARCH DAY
SCHEDULE OF EVENTS

Friday, May 17, 2013, 8:00 AM - 4:00 PM

2:45 – 4:00 **Scientific Papers, Session IV**

Braley Auditorium

Moderator: Randall J. Olson, M.D.

4th Annual Distinguished Ophthalmic Educator

Morning Session, Paper 1

Systemic associations with nasolacrimal duct obstruction

Rachel K. Sobel, M.D.

Primary Supervisor: Richard C. Allen, M.D., Ph.D.
Other Supervisor: Keith D. Carter, M.D.

Background/Purpose: Nasolacrimal duct obstruction (NLDO) is a common disorder encountered by the ophthalmologist. There is an age-related bimodal distribution with younger patients often responding well to NLD probing and older patients requiring dacryocystorhinostomy (DCR). Most commonly, NLDO is thought to result from a "primary acquired" blockage, a process of chronic inflammation in a narrowed nasolacrimal duct. However, several systemic diseases and medications have been associated with NLDO as secondary causes. It is our hypothesis that, similar to patients with uveitis, these systemic associations occur more commonly in patients who have bilateral disease. Our study will investigate the incidence of a secondary systemic disease or medication toxicity in patients with a history of bilateral NLDO as compared to patients who have unilateral NLDO.

Methods: This study is a retrospective case review of all patients who underwent bilateral DCR, either simultaneously or consecutively, from 1986 to 2012 at the University of Iowa Hospital and Clinics. Charts were examined for nasolacrimal duct-related systemic associations that occurred before or developed after the procedure. These cases were age and gender matched with controls who had unilateral DCR.

Results: Pending

Conclusion: Pending

Financial Disclosure: The authors have no financial interests to disclose.

Research at The University of Iowa Department of Ophthalmology and Visual Sciences
is supported in part by an unrestricted grant from Research to Prevent Blindness

Morning Session, Paper 2

K-Pro I outcomes

Jonathan L. Hager, M.D.

Primary Supervisor: Kenneth M. Goins, M.D.

Background/Purpose: To evaluate the clinical performance of the Boston Keratoprosthesis through four years of follow-up after initial implantation in patients with a variety of underlying corneal pathologies.

Design: Prospective, interventional, non-comparative case series.

Participants: We analyzed 50 cases of Boston Keratoprosthesis implant from April 2009 through May 2013

Methods: Clinical data was collected from patients up to 4 years after initial implantation. Pre-operative diagnoses and concomitant surgical procedures were analyzed in relationship to post-implantation visual acuities, keratoprosthesis survival rates, complication rates and types, and need for additional surgical procedures.

Main Outcome Measures: Visual acuity and keratoprosthesis survival.

Results: Pending

Conclusion: Pending

Financial Disclosure: The authors have no financial interests to disclose.

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Morning Session, Paper 3

Repair of 50-75% full-thickness lower eyelid defects: The principle of lateral stabilization

C. Blake Perry, M.D.

Primary Supervisor: Richard C. Allen, M.D., Ph.D.

Background: Repair of large full thickness defects of the lower eyelid can be difficult. A common procedure performed is a Hughes flap. This procedure has a number of disadvantages: the eye is closed post-operatively for at least two weeks; a second stage is required; there is a loss of eyelashes in the area of the flap; and the edge of the flap is often persistently erythematous.

Purpose: To describe a procedure for the repair of large full thickness defects of the lower lid which involve 50 to 75% of the horizontal length of the eyelid. The procedure employs lateral stabilization of the posterior lamella with a periosteal strip, and a myocutaneous advancement flap to stabilize the anterior lamella. For defects greater than or equal to 66% of the lower lid, a free tarsal graft is often necessary to complete posterior lamellar reconstruction. For central and medial defects, a horizontal tarsal transposition flap is used to "shift the defect laterally".

Methods: This is a non-randomized, non-comparative, retrospective case study.

Results: 38 patients underwent the procedure to reconstruct full thickness defects of the lower lid ranging from 50-75%. Twenty-three patients were female. Fifteen defects were on the right side, 23 on the left. Average age was 73.9 years. All patients underwent Mohs excision of a skin cancer: 33 patients had a basal cell carcinoma (BCC) and 5 had a squamous cell carcinoma (SCC). The average follow up was 5.6 months (all $\geq$ 4 months). Eleven patients (29%) had post-operative sequelae, 2 patients (5%) required additional treatment.

Lateral Defects: Nine patients, average age was 81.5 years. Six patients were female. Seven patients had a BCC, 2 patients had a SCC. Four defects were on the right and 5 on the left. Patients were judged to have the following size defects: 2 with 50% defect, 6 with 66% defect, and 1 with 75% defect. All 7 patients with defects greater than or equal to 66% required a free tarsal graft (FTG). The average follow up was 5.7 months. No complications were noted.

Central Defects: twenty-one patients, average age was 68.3 years. Twelve patients were female. Eighteen patients had a BCC, 3 patients had a SCC. Eight defects were on the right and 13 on the left. Patients were judged to have the following size defects: 14 with 50% defect and 7 with 66% defect. All 66% defects and 1 50% defect required a FTG. The average follow up was 5.8 months. Eight patients had post-operative sequelae: 2 patients with a misdirected lash, 1 granuloma, 1 scar (treated with Kenalog), 1 segmental trichiasis (treated with wedge resection), 2 ectropion, 1 small area of symblepharon. Only 2 were significant enough for the patient to elect for further treatment.

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Medial Defects: Eight patients, average age was 71.9 years. Five patients were female. All patients had a BCC. Three defects were on the right and 5 on the left. Patients were judged to have the following size defects: 4 with 50% defect, 4 with 66% defect. All 66% defects and 1 50% defect required a FTG. All patients underwent lower canaliculus reconstruction with stenting of the lacrimal system. The average follow up was 5.4 months. Three patients had post-operative sequelae: 1 kink of the upper lid free-tarsal graft donor site, 1 ectropion, 1 continued tearing with patent lacrimal system. No patient elected reoperation for the complication.

Conclusion: We believe this is a useful procedure to employ in the repair of full thickness defects of the lower eyelid that involve 50-75% of the horizontal length of the eyelid. The procedure has the following advantages over a Hughes flap: the eye is not closed post-operatively; a second stage is not required; eyelashes are preserved medially; and the lid margin heals well without erythema.

Lateral repositioning or shifting of the defect is critical to provide stabilization of the eyelid post-operatively. This involves transposing the native posterior lamella medially in central and medial defects. The shifting of the defect laterally then allows the development of strong stabilization of the posterior lamella with a periosteal strip. Any remaining deficit of the posterior lamella between the periosteal strip and native tarsus can be filled with a free tarsal graft. The anterior lamella can then be adequately advanced and stabilized with a myocutaneous advancement flap that engages periosteum of the inferior orbital rim and lateral orbital rim for support.

Although a critical review of the patients post-operatively shows that 29% of patients have some issue, only 5% were judged significant enough by the patient or physician to require any further surgery.

Financial Disclosure: The authors have no financial interests to disclose.

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Morning Session, Paper 4

Intravenous pentamidine for *Acanthamoeba* keratitis

Bradley A. Sacher, M.D.

Primary Supervisor: Anna Kitzmann, M.D.

Background/Purpose: *Acanthamoeba* is a free-living protozoan found in a wide variety of habitats including soil and fresh water. This protozoan can cause a serious vision threatening infection of the eye, commonly manifesting as a keratitis or sclerokeratitis. *Acanthamoeba* keratitis is rare, but difficult to treat when present. The topical treatment modalities are limited in number and effectiveness, and they can also be toxic to the cornea. At our institution there have been cases of severe *Acanthamoeba* keratitis treated with intravenous pentamidine as an adjunct to topical therapy. Presently, no published data exists which describes the use of intravenous pentamidine for patients with *Acanthamoeba* keratitis. This study will provide information about the use of intravenous pentamidine in treating *Acanthamoeba* keratitis.

Methods: We will perform a retrospective chart review of ten patients diagnosed with *Acanthamoeba* keratitis and who were treated with intravenous pentamidine between October 2002 and June 2007 at the University of Iowa. Only patients with a positive corneal epithelial biopsy and at least 12 months of follow-up after intravenous pentamidine will be included in the study. The main outcome measure is microbiological cure, defined as no clinical evidence of *Acanthamoeba* keratitis for 12 months after intravenous pentamidine administration. Secondary outcome measures include visual acuity and complication rates, such as visually significant corneal scarring, need for a corneal transplant, and development of glaucoma.

Results: pending

Conclusion: pending

Financial Disclosure: The authors have no financial interests to disclose.

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Morning Session, Paper 5

Reversibility of visual field deficits in glaucoma patients

Jesse M. Vislisel, M.D.

Primary Supervisors: W.L.M. Alward, M.D., Michael Wall, M.D.

Background/Purpose: The current dogma is that glaucomatous visual field loss is irreversible and that the goal of management is to stabilize or slow further loss as much as possible. This study seeks to determine whether the visual field in glaucoma patients can improve beyond what is expected with the perimetric learning effect, and if so, what factors of the disease and treatment regimens may correlate with this improvement.

Methods: 60 normal and 120 glaucoma patients were tested with 4 separate visual field procedures, 1) SITA size III automated perimetry, 2) full threshold size V automated perimetry, 3) Humphrey Matrix perimetry, and 4) motion perimetry twice at baseline and then every 6 months for 4-years. Another 15 normal patients and 30 glaucoma patients performed these same visual field tests every week over a 5-week period to analyze short-term variability and learning effects. These data were analyzed to assess for visual field improvement in the 4-year test subjects relative to that expected based on factors such as the learning effect. Subjects with confounding factors such as cataract extraction and corneal procedures during this time interval were excluded. Those with visual field improvement beyond what was expected were then retrospectively analyzed to assess for any commonalities in disease characteristics and management.

Results: Pending

Conclusion: Pending

Financial Disclosure: The authors have no financial interests to disclose.

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Morning Session, Paper 6

Deviation from the optimal branching relationship of retinal vessels in diabetes mellitus

Angela R. McAllister, M.D.

Primary Supervisor: Michael D. Abràmoff, M.D., Ph.D.
Other Supervisor: Xiayu Xu, Ph.D.

Background/Purpose: Deviations of the relationship between the diameter of the parent and the two daughter branches of a vessel bifurcation have been associated with vascular disease. The optimal relationship, known as Murray's Law, states that the most favorable relationship occurs when the cube of the radius of the parent vessel is equal to the sum of the cubes of the radii of the daughter blood vessels. We propose to study this association in people with type II diabetes with little or no clinical signs of diabetic retinopathy.

Methods: Retinal color images were obtained from 874 people with type II diabetes, in which the prevalence of retinopathy is 20% (Abramoff *et al*, JAMA Ophthalmology 2013). A fully automated method was used to determine the widths of each branch at each crossing, using our previously validated algorithm. From the above population, a subset was randomly selected for branch point measurement. Linear regression was used to find the power that best described the relationship between the arterial and venous radii.

Results: Arterial and venous branches were measured on photos from 50 subjects from the diabetes population and on 150 fundus images from a normal population. From the diabetic population, 285 arterial branches and 379 venous branches were measured. The best fit power relationship was 5.0 and 3.3 for arterial and venous bifurcations respectively. From the normal population, 331 arteriolar branches and 573 venous branches were measured. The parent branch-daughter branch artery relationship fit Murray's Law well with a third power relationship while the relationship in venous branches demonstrated a best fit of 2.4.

Conclusion: The apertures of the branches of arterial and venous bifurcations in the diabetic population deviate from the normal subjects. The daughters are wider than predicted by Murray's Law. Previously, increased arterial flow and vessel wall irregularities have been described in subjects with diabetes. Possibly vessel widening is related to increased flow rate to maintain resistance and increased diameter compensates for increased resistance per unit area of vessel wall. Our findings may have important implications for early detection of retinal disease from diabetes mellitus even before retinopathy is clinically evident.

Financial Disclosure: Abramoff, Xu: Patent.

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is supported in part by an unrestricted grant from Research to Prevent Blindness

Morning Session, Paper 7

Combined pars plana vitrectomy and glaucoma drainage implant insertion

Elizabeth H. Gauger, M.D.

Primary Supervisor: Vinit B. Mahajan, M.D.
Other supervisor: Young Kwon M.D., Ph.D.

Background/Purpose: To determine the uses and efficacy of combined pars plana vitrectomy and glaucoma drainage device implants in patients with glaucoma.

Glaucoma drainage implants (GDIs) are utilized in cases of refractory glaucoma. These devices have a silicone tube that is most commonly inserted into the anterior chamber to shunt intraocular fluid to a reservoir that is located posterior to the limbus. However, in specific situations, such as in patients with shallow anterior chambers or posterior pathology, the GDI is inserted in the posterior chamber. Because vitreous can occlude the tube, a pars plana vitrectomy (PPV) may be performed at the same time.

Design: A retrospective chart review of patients who underwent combined pars plana vitrectomy (PPV) and GDI insertion at the University of Iowa.

Methods: After Institutional Review Board approval was obtained, potential study patients were identified by review of the Mahajan vitrectomy surgery database from 2008 to 2013. A total of 21 patients were identified that met criteria. Inclusion criteria were: preoperative IOP data, visual acuity, type of implant placed, and postoperative IOP data for 6-12 months. Data recorded included: preoperative IOP and visual acuity, underlying glaucoma diagnosis, IOP data for specified post-operative time intervals, post-operative visual acuity, age at time of procedure, and post-operative glaucoma therapy.

Results: We identified 21 patients that met all inclusion criteria. The average age of the patients was 27.8 years. Average pre-operative IOP was 32.5mmHg on an average of three topical IOP-lowering medications. A total of 9 Ahmed setons were placed (43%) and 12 Baerveldt setons (57%). The most common indication for combined PPV and GDI was aphakic glaucoma (57%). The average IOP 12 months post-operatively was 14.8mmHg on an average of one glaucoma medication. There was no 12-month data yet for 11 of the 21 patients, but the six-month data revealed an average IOP of 15.8mmHg. There was no tube occlusion in the postoperative period.

Conclusions: Combined PPV and GDI placement can be successful in lowering IOP in a select patient population, especially in those with aphakic glaucoma.

Financial Disclosure: The authors have no financial interests to disclose.

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Morning Session, Paper 8

Limiting Infectious Complications in Boston Type I Keratoprosthesis

Jeffrey D. Welder, M.D.

Primary Supervisor: Mark A. Greiner, M.D.
Other Supervisors: Kenneth M. Goins, M.D. Anna S. Kitzmann, M.D., Matthew S. Ward, M.D.

Background/Purpose: Infectious complications after Boston Type 1 keratoprosthesis (KPro) implantation, especially endophthalmitis, can have devastating effects on vision and lead to permanent impairment. There is a continuous risk of infection, in part, because the device's elevated anterior plate and surrounding donor epithelium constitute an altered barrier exposed constantly to a non-sterile ocular surface environment. Traditional management after KPro surgery includes chronic topical antibiotic and steroid eye drops to help sterilize the ocular surface and control the host immune response, respectively, and a bandage contact lens is used to help prevent epithelial defects. Surgeons frequently utilize a combination of antibiotic eye drops to achieve broad-spectrum and resistant-strain antibacterial coverage, such as vancomycin with a 3rd or 4th generation fluoroquinolone, including surgeons here at the University of Iowa Hospitals and Clinics (UIHC). However, increased occurrences of fungal and bacterial endophthalmitis prompted UIHC corneal surgeons in 2011 to institute a quarterly prophylaxis regimen designed to reduce the incidence of infection. The purpose of our study is to report the post-operative infectious complications in KPro implantation at UIHC and evaluate standard antimicrobial prophylaxis versus an augmented antimicrobial prophylaxis regimen, which includes scheduled Betadine rinses and topical antifungal therapy in addition to standard prophylaxis.

Methods: A retrospective chart review will be performed on eyes that received a KPro implant at the University of Iowa. Patients with infectious complications will be reviewed for demographic data, indication for surgery, postoperative prophylaxis regimen, presentation and timing of infectious complication(s), microbial assay and culture results, response to therapy, visual outcome, and other surgical procedures including device replacement and explantation. A comparison will be made between patients receiving the standard antimicrobial regimen of vancomycin (16mg/mL), a 3rd or 4th generation fluoroquinolone, and quarterly bandage contact lens replacement and an augmented regimen incorporating Betadine rinses and 7 days of amphotericin B (0.15%) every 3 months.

Main Outcome Measures: Incidence of infectious complications, causative organisms and sensitivities, time to occurrence, and visual outcomes in both groups.

Results: Pending. To include percentages of eyes diagnosed with infectious complications by type, presentation, organism and sensitivity. Will include comparison of results from standard versus augmented antimicrobial prophylaxis regimens.

Conclusions: Pending. Infection after KPro implantation remains a significant vision-threatening complication. Antimicrobial prophylaxis regimens have evolved to target Gram-negative organisms and fungi in addition to Gram-positive organisms. The addition of scheduled Betadine rinses and topical amphotericin-B to standard antibiotic drops and contact lens replacement may decrease infectious complications after KPro surgery.

Financial Disclosure: The authors have no financial interests to disclose.

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Morning Session, Paper 9

Leinfelder Award-Winning Paper

Diaton tonometry in patients with ocular hypertension, glaucoma, and glaucoma drainage devices—A preliminary study for its potential use in keratoprosthesis patients

Justin M. Risma, M.D.

Primary Supervisor: Young H. Kwon. M.D., Ph.D.
Other Supervisors: Shandiz Tehrani, M.D., Ph.D.; John H. Fingert, M.D., Ph.D.; Wallace L.M. Alward, M.D.

Background/Purpose: Glaucoma is one of the most common and debilitating complications of the Boston type 1 keratoprosthesis (KPro). Many patients require the placement of a glaucoma drainage device (GDD). Because of the inability to perform corneal applanation, digital palpation is currently the standard method for estimating intraocular pressure (IOP) in KPro patients. The Diaton tonometer estimates IOP by transpalpebral scleral indentation and has shown fair reliability in normal patients with normal IOP. The purpose of this study was to determine whether the Diaton tonometer can reasonably detect high IOP in patients with ocular hypertension, glaucoma, or GDDs. If reliable in these settings, it may be helpful in estimating IOP in KPro patients.

Methods: We prospectively performed Goldmann applanation tonometry (GAT) and Diaton transpalpebral tonometry (DTT) in 87 eyes of 57 adult patients with ocular hypertension, glaucoma, or GDDs. DTT was performed on the upper and lower eyelids. Patients with a history of corneal transplantation, an elevated bleb, or gross eyelid abnormalities were excluded.

Results: The correlation coefficient between GAT and DTT of the upper eyelid was 0.635 ($p < 0.0001$). There was no correlation between GAT and DTT of the lower eyelid. Central corneal thickness correlated with GAT ($p = 0.0041$), but not with DTT. For detecting an IOP of >21 mmHg as measured by GAT, DTT on the upper eyelid had a sensitivity and specificity of 65% and 81%, respectively. The positive and negative predictive values were 74% and 73%, respectively. The presence of a GDD did not significantly affect the results.

Conclusions: DTT showed modest reliability as a screening tool for elevated IOP in patients with glaucoma, ocular hypertension, and GDDs. Further research is needed to elucidate the effect of a KPro on DTT readings, but DTT may be a useful supplement to digital palpation for KPro patients.

Financial Disclosure: The authors have no financial interests to disclose.

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Afternoon Session, Paper 1

Visual loss after contact lens-related *Pseudomonas* keratitis

Matthew C. Weed, M.D.

Primary Supervisor: Michael D. Wagoner, M.D., Ph.D.
Additional Supervisors: Kenneth M. Goins, M.D., Anna S. Kitzmann, M.D.; Gina R Rogers, M.D.; John H. Sutphin, M.D.; Matthew S Ward, M.D.

Background/Purpose: To determine the frequency and extent of visual loss that occurs in eyes with excellent visual acuity and no risk factors for microbial keratitis after the development of contact lens-related *Pseudomonas* keratitis.

Methods: A retrospective chart review was performed of all cases of culture-positive *Pseudomonas aeruginosa* keratitis that presented to the Cornea Service between 1 July 2006 and 30 July 2011. Inclusion criteria were a history of contact lens use at the time of the onset of the corneal infection, involvement of the central 6 mm of the cornea on presentation, and more than 6 months of follow-up. Exclusion criteria included a pre-infectious best corrected visual acuity (BCVA) less than 20/20, history of anterior segment surgery, treatment for ocular surface disorders, or use of any topical ocular medications. The main outcome measure was final visual outcome after all surgical interventions. Mild visual loss was defined as a final BCVA that was between 20/25 and 20/40; moderate visual loss was defined as a final BCVA between 20/50 and 20/200; and severe visual loss was defined as a final BCVA that was worse than 20/200.

Results: Eight eyes met the inclusion criteria. The mean patient age was 35.5 years (range, 19 to 69). All eight cases were associated with overnight wear of extended wear soft contact lenses. At the time of initial presentation, the median BCVA was hand motion (range, 20/60-light perception). The mean maximum diameter of the stromal infiltrate was 4.0 mm (range, 1.5-6.0 mm), and the mean minimum diameter was 3.6 mm (range, 1.5-5.5 mm). The initial depth was estimated to be less than 50% in 4 eyes (50.0%), and greater than 90% in 2 eyes (25.0%). A hypopyon was present in 6 eyes (75.0%). A microbiological cure was achieved in all 8 eyes with medical therapy alone. After a mean follow-up of 8.7 months, the median BCVA was 20/50 (range 20/20 to hand motion). Seven eyes (87.5%) experienced mild (2 eyes), moderate (2 eyes), or severe (3 eyes) vision loss prior to undergoing rehabilitative surgical intervention. An optical penetrating keratoplasty was performed in 3 eyes with post-infectious scarring after a mean interval of 8.6 months (range, 4.8-13.5 months) from initial presentation. After a mean follow-up period of 43.2 months (range, 30.0-59.2 months), the grafts remained clear, with a final BCVA of 20/20 in 2 eyes and 20/30 in 1 eye. After all surgical interventions, the final median BCVA among all eight eyes was 20/25 (range, 20/20 to 20/50). Five eyes (62.5%) experienced mild (n = 3; BCVA = 20/25, 20/25, 20/30) or moderate (n = 2; BCVA = 20/50, 20/50) visual loss. No statistically significant correlation was detected between initial size or depth of the infiltrate, presence or absence of hypopyon, and timing of initiation of topical steroid therapy and the visual outcome after completion of all therapeutic interventions.

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Conclusion: Medical therapy is very effective in achieving a microbiological cure in most cases of contact lens-related *Pseudomonas* keratitis. Unfortunately, most cases involving the visual axis are associated with loss of best-corrected visual acuity despite optimal medical therapy. Vision loss may be severe in many cases and require optical keratoplasty for visual rehabilitation. The increased convenience of extended contact wear over daily wear does not justify the assumption of the additional risk of development of this sight-threatening complication for routine correction of refractive errors.

Financial Disclosure: The authors have no financial interests to disclose.

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Afternoon Session, Paper 2

Leinfelder Award-Winning Paper

Acute optical coherence tomography changes over involuted choroidal neovascularization in the presumed ocular histoplasmosis syndrome

Matthew A. Cunningham, M.D.

Primary Supervisor: James C. Folk, M.D.

Importance: To assess a finding on optical coherence tomography (OCT) in patients with the presumed ocular histoplasmosis syndrome (POHS), which indicates an early sign of reactivation of a choroidal neovascular membrane (CNV).

Objective: To determine the cause and clinical outcome of hyperintense material overlying a stable scar from previously treated CNV in POHS

Design: Retrospective study of 50 consecutive patients who were diagnosed with POHS at the University of Iowa.

Setting: Tertiary care referral center.

Participants: The last 50 consecutive patients (100 eyes) diagnosed with POHS. All patients had undergone spectral-domain OCT testing.

Intervention(s): Intravitreal injections of bevacizumab, or triamcinolone acetonide.

Main Outcome Measure(s): The progression or resolution of the hyperintense material and CNV on serial OCT testing in patients with or without treatment.

Results: Review of photographs and OCTs of 100 eyes revealed that 19 eyes had an active CNV; 29 eyes had a stable fibrotic scar, and 16 eyes had an atrophic scar/histo spot in the posterior pole. The hyperintense material was seen on OCT in 8 of 19 eyes (42.1%) with an active CNV; 7 of 29 eyes (24.1%) with a fibrotic scar; and none of the eyes with an atrophic histo scar. In the patients with fibrotic scars who had been stable after treatment, the material was the first sign of reactivation of the CNV. The hyperintense material resolved or diminished after treatment with anti-VEGF agents.

Conclusions and Relevance: Hyperintense material is often seen overlying scars on OCT in eyes with POHS and active or stable scars from previous CNV. This material, and not subretinal or intraretinal fluid, is usually the first sign of reactivation of a CNV in a patient who has been stable after anti-VEGF treatment. We believe it is an important early OCT sign indicating reactivation of a CNV and treatment should be considered even in the absence of fluid.

Financial Disclosure: The authors have no financial interests to disclose.

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Afternoon Session, Paper 3

Iron deposition in ocular tissues of young children: An autopsy series

Meagan D. Seay, D.O.

Primary Supervisor: Nasreen A. Syed, M.D.
Other Supervisor: Christy Ballard

Background/Purpose: To determine the incidence of iron deposition in selected ocular tissues of young children deceased from accidental/natural causes.

Methods: A review of all pediatric eye autopsy cases performed at the F.C. Blodi Eye Pathology Laboratory from 2003-2013 was completed. Of the 98 total cases, 25 had a manner of death attributed to accidental or natural causes. If not already performed, Perls' Prussian blue stain for iron was performed on two levels of anterior segment, posterior segment, and optic nerve for each of the 25 cases. Slides were then evaluated for the presence of iron primarily in the retina and optic nerve sheath by two masked, independent evaluators. The sections were graded as positive if iron deposition was noted in ocular tissues.

Results: Pending

Conclusion: Pending

Financial Disclosure: The authors have no financial interests to disclose.

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Afternoon Session, Paper 4

The optic nerve head actin cytoskeleton and its role in glaucoma

Shandiz Tehrani, M.D., Ph.D.

Primary Supervisor: Markus H. Kuehn, Ph.D.
Other Supervisors: Elaine C. Johnson, William O. Cepurna, Matthew R. Bald, Amy C. Cook, John C. Morrison

Background/Purpose: To assess the structure and cellular origin of the filamentous actin (F-actin) optic nerve head (ONH) cytoskeleton in normal and glaucomatous rat and human eyes.

Methods: Unilateral IOP elevation was produced in rats by episcleral injection of hypertonic saline and tissues collected at 5 weeks. Optic nerve axonal degeneration in rats was graded on a scale of 1(normal)-5 (extensive) by light microscopy. Longitudinal sections of rat ONH were co-labeled with phalloidin and antibodies to astrocytic aquaporin (Aqp4), glial fibrillary acid protein (GFAP), or axonal tubulin βIII (Tuj1) to further elucidate the cellular origin of F-actin and its relationship to axons. Longitudinal human ONH sections (normal, ocular hypertensive, and glaucoma) were labeled with phalloidin or Tuj1.

Results: Untreated rat ONH showed densely arranged F-actin bundles oriented perpendicular to the vertical axis, and to Tuj1 labeled axons, in a pattern most consistent with the orientation of astrocytic processes in the glial lamina. Additionally, F-actin labeled the walls of the ONH vascular components. F-actin partially co-labeled with Aqp4, further suggesting the astrocytic origin of the dense F-actin bundles. Labeling intensity analysis of glaucoma model eyes suggested astrocytic structural changes, as indicated by reduced F-actin labeling in eyes with mild-moderate injury. With greater injury in the rat model, the ONH actin cytoskeleton became exceedingly disorganized with an increase in F-actin fluorescence intensity, possibly due to astrocytic remodeling in response to injury. In contrast, in transected rat ONH, F-actin remained relatively preserved, suggesting that the changes in the F-actin cytoskeleton with IOP elevation were not simply secondary to non-specific axonal injury. In humans, F-actin localized to the pre-laminar, laminar, and post-laminar ONH, with fine actin processes interdigitated between axonal bundles. Preliminary F-actin and axonal immunofluorescence intensity analyses in normal, ocular hypertensive and glaucomatous human eyes are underway.

Conclusion: The actin cytoskeleton of the rat ONH is a dense structure that may have a specific role in early and late ONH remodeling in response to glaucomatous injury. F-actin labeling within the rat and human ONH appears to highlight the glial lamina and astrocytic processes, respectively. In addition, F-actin labeling highlights the vascular components of the ONH.

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Afternoon Session, Paper 5

Fluocinolone acetonide implant inhibits neovascularization but not fibrosis in autosomal dominant neovascular inflammatory vitreoretinopathy

Paul S. Tlucek, M.D.

Primary Supervisor: Vinit B. Mahajan, M.D., Ph.D.
Other Supervisors: James C. Folk M.D., Edwin M. Stone M.D., Ph.D.

Objective: To review the effect of the fluocinolone acetonide implant (FA) in subjects with Autosomal Dominant Neovascular Inflammatory Vitreoretinopathy (ADNIV), an inherited, autoimmune uveitis.

Methods: A retrospective case series was assembled from ADNIV patients who underwent fluocinolone acetonide implantation. Visual acuity and features of ADNIV, including inflammatory cells, neovascularization, fibrosis, and cystoid macular edema were reviewed.

Results: Nine eyes of five related ADNIV patients with uncontrolled inflammation were reviewed. Follow-up ranged 21.7–56.7 months. Vision at implantation ranged from 20/40 to hand motion. Preoperatively, eight eyes demonstrated vitreous cell (a ninth had diffuse vitreous hemorrhage). Eight eyes demonstrated cystoid macular edema, seven had an epiretinal membrane, and three manifested retinal neovascularization. Following implantation, vitreous cells resolved in all eyes and neovascularization regressed or failed to develop. Central macular thickness improved in four eyes. During the postoperative course, however, visual acuity continued to deteriorate, with vision at the most recent examination ranging from 20/60 to no light perception. There was also progressive intraocular fibrosis and phthisis in one case. Four eyes underwent cataract surgery. Six of the seven eyes without previous glaucoma surgery demonstrated elevated intraocular pressure at some point, and three of these required glaucoma surgery.

Conclusions: FA implantation may inhibit specific features of ADNIV such as inflammatory cells and neovascularization, but does not stabilize long-term vision, retinal thickening, or fibrosis. All eyes in this series required cataract extraction, and more than half required surgical intervention for glaucoma. Further studies may identify additional therapies and any benefit of earlier implantation.

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Afternoon Session, Paper 6

Graft survival after penetrating or Descemet's stripping automated endothelial keratoplasty for corneal edema in eyes with and without glaucoma therapy

Matthew Ward, M.D.

Primary Supervisor: Michael D. Wagoner, M.D., Ph.D.
Other Supervisors: Kenneth M. Goins, M.D.; Mark Greiner, M.D.; Anna S. Kitzmann, M.D.; John E. Sutphin, M.D.; M. Bridget Zimmerman

Background/Purpose: To assess the association of glaucoma therapy on corneal graft survival after penetrating keratoplasty (PKP) and Descemet's stripping automated endothelial keratoplasty (DSAEK) in eyes with corneal edema.

Methods: A retrospective chart review was performed of all patients undergoing either primary penetrating keratoplasty (PKP) from January 1, 2003 to December 31, 2005 or primary Descemet's stripping automated endothelial keratoplasty (DSAEK) from January 1, 2006 to December 31, 2008 for phakic, aphakic, or pseudophakic corneal edema in which at least one year of follow up was available. The PKP inclusion dates prior to December 31, 2005 were selected instead of contemporary cases, since the latter situation would have sorted good prognosis cases for DSAEK and poor prognosis cases for PKP and imparted bias to the study. Instead, the selection of cases from an era when DSAEK was not available made it possible to identify those cases that would have been offered DSAEK at a later date. In order to have similar follow-up potential for two study groups in this non-simultaneous, comparative study, the follow up cut-off date for the PKP patients was December 31, 2009, and December 31, 2012 for the DSAEK patients. This allowed each group to have a minimum and maximum eligibility of 4 years and 7 years, respectively.

Within each surgical category, eyes were divided into three groups; (1) no need for glaucoma therapy; (2) need for glaucoma medical therapy at any point in the clinical course; (3) need for glaucoma surgical intervention at any point in the clinical course. The main outcome variable was graft survival. Five-year Kaplan Meier (K-M) graft survival tables were created for: (1) PKP cases with each of the three glaucoma subcategories; (2) DSAEK with each of the three glaucoma surgical categories, and (3) for a comparison between PKP and DSAEK graft survival with identical glaucoma situations. Bonferri adjusted p-values were used to identify statistical differences, if any, between the K-M survival curves.

Results: Fifty-five PKP patients met the inclusion criteria. In the PKP groups, grafts failed in 2 of 29 eyes (6.9%) that had no glaucoma therapy, 2 of 17 (11.8%) eyes with glaucoma medical therapy, and in 4 of 9 (44.5%) eyes with glaucoma surgery (P = 0.02). Five-year K-M survival was 94.7% (95% confidence interval (CI) 0.681-0.992) in eyes with no glaucoma therapy, 93.8% (95% CI: 0.632-0.991) in eyes with glaucoma medical therapy, and 56.8% (95 % CI: 0.213-0.813) in eyes with glaucoma surgery. The difference in survival between eyes with no glaucoma and those that required surgical therapy approached statistical significance (P = 0.057).

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One hundred and fifty-six DSAEK patients met the inclusion criteria. In the DSAEK group, grafts failed in 5 of 105 eyes (4.7%) that had no glaucoma therapy, in 6 of 42 (14.3%) eyes with glaucoma medical therapy, and 5 of 9 (55.6%) eyes with glaucoma surgery (P = 0.0002). Five-year K-M survival was 96.4% (95% CI: 0.860-0.991) in eyes with no glaucoma therapy, 96.3% (95% CI: 0.772-0.995) in eyes with glaucoma medical therapy, and 50.0% (95% CI: 0.115-0.992) in eyes with glaucoma surgery. There was a statistically significant difference in survival between eyes with no glaucoma and those that required surgical therapy (P = 0.00018).

There were no significant differences in 5-year K-M survival of PKP vs. DSAEK with no glaucoma (94.7% *vs* 96.3%; P > 0.99), PKP *vs* DSAEK with glaucoma medications only (93.8% *vs* 96.4%; P > 0.99) or PKP *vs* DSAEK with glaucoma surgery (56.8% *vs* 50.0%; P > 0.99).

Conclusion: The need to perform glaucoma surgery at any point in the clinical course of an eye undergoing PKP or DSAEK for corneal edema is significantly associated with an increased risk of graft failure. Approximately 50% of such grafts can be expected to fail within five years of keratoplasty, even with excellent control of intraocular pressure during the entire clinical course.

Financial Disclosure: The authors have no financial interests to disclose.

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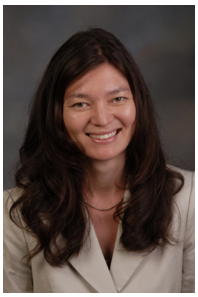
Afternoon Session, Paper 7



The ganglion cell layer across the vertical meridian in hemianopsia: I get no respect!

Kimberly M. Winges, M.D.

Primary Supervisor: Randy H. Kardon, M.D., Ph.D.

Background/Purpose: Since the vertical midline is respected in classic homonymous (HH) and bitemporal hemianopsia (BH), resulting loss of retinal ganglion cells should also stop at the vertical meridian in lesions of the optic tract or chiasm. However, anatomic labeling studies demonstrate retinal ganglion cell (RGC) soma located in the hemiretina that show "spillover" across the vertical meridian.[1,2,3] Spectral domain optical coherence tomography (SD-OCT) was used to analyze whether the distribution of loss in the macula crosses this anatomic threshold in such patients.

Methods: 18 eyes (15 patients) with BH and 12 eyes (7 patients) with HH on kinetic and standard automated perimetry underwent fields and macular SD-OCT on the same day. Probability maps of the ganglion cell layer plus inner plexiform layer (GCIPL) were analyzed for horizontal extent of thinning beyond the vertical meridian, corresponding to the normal visual hemifield. Extent was measured in degrees (deg), with thinning measured at the 5% level of the normative database.

Results: Mild spillover of GCIPL thinning into the seeing hemifield was observed in 7 BH eyes (mean 1.92 deg; range 0.75 to 2.88 deg) and in 9 HH eyes (1.16 deg; 0.33 to 2.33 deg). However, 11 BH eyes showed marked spillover of GCIPL thinning into the temporal retina despite midline-respecting visual field defects (6.47 deg; 4.33 to 8.38 deg) versus 3 eyes in the HH group (6.53 deg; 3.81 to 8.29 deg). In total, BH eyes demonstrated significantly thinner GCIPL in the seeing hemifield than HH eyes ($p < 0.005$, t-test).

Conclusions: With visual field defects respecting the vertical meridian, homonymous hemianopsia-producing tract lesions show mild spillover of ganglion cell loss across the vertical meridian, consistent with anatomic RGC studies. In contrast, most eyes with bitemporal hemianopsia demonstrate much greater GCIPL spillover, suggesting atrophy of non-crossing axons that is not apparent on visual field testing.

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Afternoon Session, Paper 8

Resident versus fellow participation in virgin horizontal rectus strabismus surgery: Impact on level of training of assistant on operative time and cost

Timothy W. Winter, D.O.

Primary Supervisor: Susannah Q. Longmuir, M.D.
Other Supervisors: Richard J. Olson, M.D.; Scott A. Larson, M.D.; Thomas A. Oetting, M.D., M.S.

Purpose: To investigate the effect of the level of training of assistants on operative time and cost of virgin, 2 horizontal muscle strabismus surgery at the University of Iowa.

Background: Additional operative time for general surgery cases as well as cataract surgery cases with resident participation has been described. At our academic center, strabismus surgery is performed under general anesthesia with either a resident (PGY3) or fellow assistant (≥PGY5). The fellow has more surgical experience than the resident and the effect of the level of training of the assistants on operative time in strabismus surgery has not been investigated.

Main outcome measures: Operative times.

Secondary outcome measures: Cost associated with operative time.

Methods: Retrospective chart review of 993 strabismus surgeries. The study included patients who underwent virgin, 2 horizontal muscle strabismus surgery by one of three attending surgeons with either a resident or a fellow as assistant between July 1, 2008 and December 31, 2012. Patients were excluded for re-operations, surgery for strabismus associated with scleral buckle, restrictive muscle disease. Combined cases with other services were also excluded.

Results: A total of 373 cases met inclusion criteria. There were 200 resident cases with an average operative time of 62.5 minutes versus 173 fellow cases with an average operative time of 59.0 minutes; the difference in operative times was 3.5 minutes and was statistically significant (p=0.02). No statistically significant variation in operative times was demonstrated when comparing residents (p=0.29) and fellows (p=0.44) in their respective first and last quarter of the year. The average per minute operating cost for strabismus surgery is between $41 and $47 per minute at our institution, thus the average cost of training residents over fellows is as much as $118 per case. Using the average of 19.1 cases/resident at the University of Iowa, the average cost per resident per year may be as high as $3,141.95.

Conclusion: Resident participation in straightforward horizontal strabismus surgery may increase operative time and cost, but the clinical relevance to the patient is unknown. Future studies may clarify the significance of increased anesthesia time and the relationship between operative time and strabismus surgery competency.

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