Surgery Symposium 3
Opportunity Cost of Vitreoretinal Surgeries

- Ella Leung, MD
- Henry Leder, MD
- Shriji Patel, MD, MBA
- Rahul Reddy
- Nick Boucher
- Chakshu Sharma
- Jill Blim, MS
- Philip Ferrone, MD, FASRS
- Paul Hahn, MD, PhD, FASRS

Objective:
To determine the opportunity cost for a physician performing vitreoretinal surgery compared to office-based patient care of equivalent time during the global period.

Purpose:
To compare physician reimbursements for vitreoretinal surgeries with office-based patient care.

Methods:
A theoretical model was performed from the surgeon's perspective comparing the physician reimbursements for the 10 most common vitreoretinal surgeries (Common Procedural Terminology (CPT) codes 67036, 67039, 67040, 67041, 67042, 67043, 67107, 67108, 67113, and 67121) with the equivalent office-based work relative value units (wRVUs) that could have been generated during the same global time period. The reimbursement rates and perioperative times were based on the 2019 values set by the Centers for Medicare and Medicaid Services (CMS), and the average wRVU per clinical visit was based on real-world 2019 data from the Vestrum Retinal Healthcare Database.

Results:
For a physician who would typically manage 40 patients per 8 hour clinical day, the physician could be reimbursed an average of 15.4 wRVU (range: 12.1-19.0) for uncomplicated surgery but could have instead generated a mean of 37.5 wRVU (range: 31.1-48.6) from office-based patient care in the equivalent time during the 90 day global period. These common vitreoretinal surgeries represented a mean opportunity cost of 59% (range: 51-71%) of potential office-based productivity. In order to neutralize the opportunity cost associated with these surgeries and their global period care, a surgeon would need to complete the surgery and all immediate perioperative care in 10 minutes (range: -5 to 20).

Modeling a clinician who saw 30 patients per day identified an average opportunity cost of 40% (range 33-58%); the break-even time was 40 minutes (range: 18-58). A busier clinician who saw 50 patients per day would lose on average 69% (range 63-78%) of potential office-based productivity, with a surgical break-even time of -5 minutes (range: -16 to 2).

Conclusion:
CMS reimbursements for the ten most common vitreoretinal surgeries represented a significant opportunity cost for the physician relative to office-based patient care, especially for busier clinicians. Breakeven times for surgery to neutralize the opportunity costs are unlikely to be achievable.

IRB APPROVAL

Surgery Symposium 3
Economic Impact of Retina Procedure Volume Changes Due to the COVID-19 Pandemic: Analysis of 2020 Medicare Data

- Shriji Patel, MD, MBA
- Avni Finn, MD, MBA
- Stephen Kim, MD
- Paul Sternberg, MD

Objective:
How has retina procedure volume changed in the Medicare population due to the COVID-19 pandemic and what was the economic impact?

Purpose:
The COVID-19 pandemic resulted in nationwide healthcare interruptions and postponement of nonurgent procedures and surgeries. Retina providers, despite furnishing vision-saving interventions, were hindered in their ability to treat patients. The authors sought to better understand the impact of the COVID-19 pandemic on provider procedure and surgery volume.

Methods:
Centers for Medicare and Medicaid Services (CMS) data for 2017-2020 were collected to assess trends over time. The most commonly code vitreoretinal procedures and surgeries in the Medicare Part B population were assessed to gauge % change compared to the previous year. Allowed charges were calculated to understand the economic impact of the changes in procedure output.

Results:
Of the 12 vitreoretinal procedures and surgeries studied in this analysis, all experienced volume declines in 2020, with an average decrease of 16.2% (range -5.1% to -25.4%) compared to 2019 (Figure). This resulted in a $42 million dollar reduction in total CMS reimbursement payments to retina providers compared to 2019, representing an 8.6% decrease. This amounted to an average reimbursement reduction in 2020 of $13,514 per provider for the retina procedures analyzed.

Conclusion:
The COVID-19 pandemic caused a significant decline in retina procedure volume in 2020 along with reduced reimbursement payments to retina practices.

IRB APPROVAL No - exempt
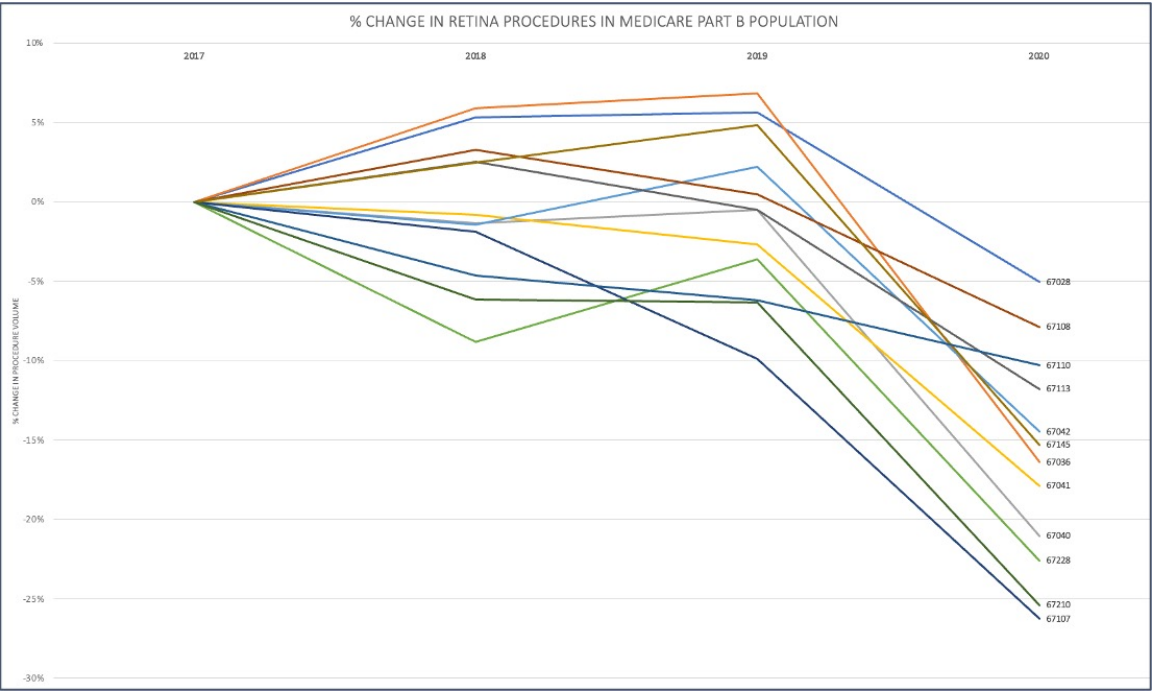
% CHANGE IN RETINA PROCEDURE VOLUME 2017-2020

Surgery Symposium 3

Feature Tracking and Image Segmentation in Real Time via Deep Learning in Vitreoretinal Surgery: Framework for AI-Mediated Surgical Guidance

- Yannek Leiderman, MD, PhD
- Rogério Nespolo, MSc
- Emily Cole, MD, MPH
- Daniel Wang, MD
- Alexis Warren, MD
- Darvin Yi, PhD

Objective:
Can the application of artificial intelligence-based image processing tools differentiate and track anatomical landmarks and surgical instruments during pars plana vitrectomy in real time?

Purpose:
Semantic image segmentation allows for network-based identification and tracking of relevant image features in real time. We have applied deep learning tools to video output from vitreoretinal surgery in order to track salient features, i.e., the optic disc, macula, microsurgical instruments, endolaser spots, retinal tears, retinal detachment, macular hole, and fibrovascular proliferation. AI-based feature identification and tracking is an essential component to creating a true guidance system for vitreoretinal microsurgery.

Methods:
Surgical video from 101 de-identified cases recorded using commercially available optical- and stereo digital surgical microscopes was utilized. Three vitreoretinal surgeons annotated 606 fundus frames extracted from surgeries performed to address a spectrum of pathologic conditions. K-fold cross-validation was employed, and the dataset was organized as follows: 20% of the annotations were reserved for the final test dataset (number of eyes, n = 20), while the remaining eyes were partitioned among training and validation datasets. A fully convolutional instance segmentation model based on YOLACT++ was trained and implemented for this study. Object detection and object segmentation performance were evaluated by calculating the area under the precision-recall curve (AUPR) for each feature tracked and segmented.

Results:
Our model detected and classified the vitrector tooltip with a mean AUPR of 0.972±0.009. Segmentation of target tissues such as optic disc, fovea, and macular hole reached mean AUPR values of 0.928±0.013, 0.844±0.039, and 0.916±0.021, respectively. Model performance was relatively independent of variation in image magnification (optical zoom) and heterogeneous fundus pigmentation. Figures 1 shows a sample frame processed by the platform.

Conclusion:
An image-processing platform based on instance segmentation using DNNs that extract features during vitreoretinal procedures can identify salient image features in real time. The platform described herein reliably retrieved spatial data for retinal elements and surgical instrumentation, achieving an AUPR of over 90% for the detection of vitrector and membrane forceps tooltips, while detecting features such as the optic disc, retinal tears and detachment, and macular holes at similar performance. Reliable real-time semantic image segmentation is a critical element in creating an AI-based microsurgical guidance environment for vitreoretinal surgery.

IRB APPROVAL Yes

Semantic Image Segmentation During Vitreoretinal Surgery
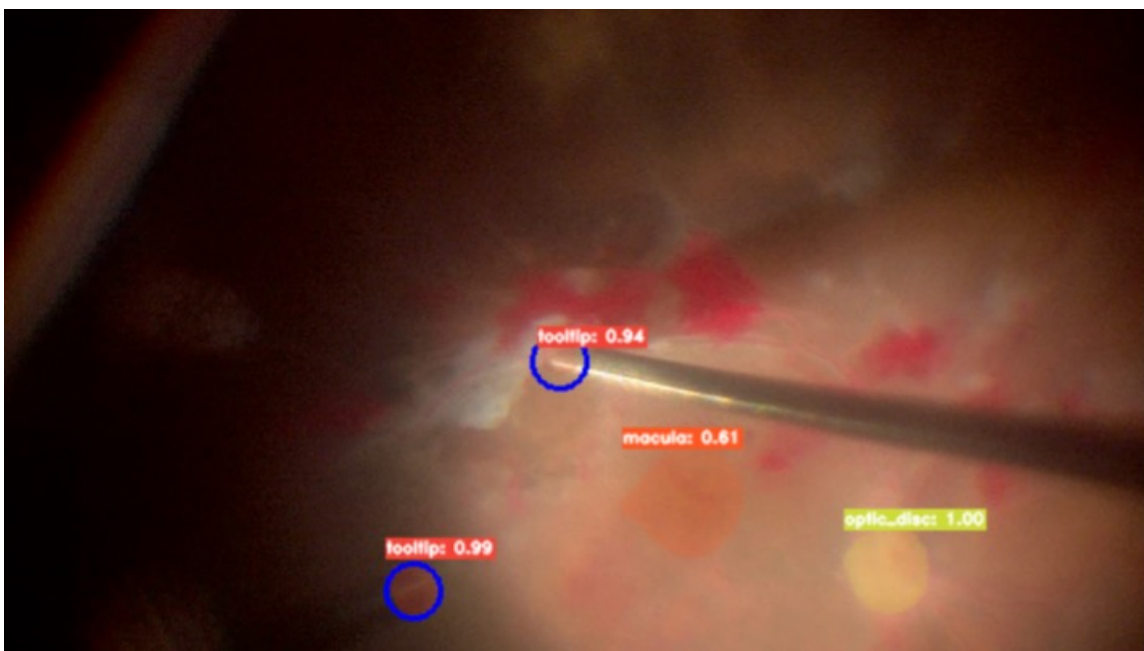
Surgery Symposium 3
Novel Technique for Capsular Tension Ring Explantation With Concomitant Intraocular Lens Exchange

- Howard Fine, MD, MHSc
- Konstantin Astafurov, MD, PhD
- Jonathan Prenner, MD, FASRS

Objective:
The goal of this study is to describe a novel surgical technique for explantation of a capsular tension ring with concomitant intraocular lens exchange in cases of posterior dislocation of the CTR-IOL-capsular complex.

Purpose:
Explantation of a dislocated capsular tension ring (CTR) from the vitreous cavity is often a challenging procedure typically requiring a bimanual hand-shake forceps technique or cutting the CTR into pieces, as described in prior literature. We present 3 cases of a dislocated intraocular lens (IOL) with dislocated CTR in the capsular bag complex in which CTRs were explanted efficiently and safely by employing a CTR inserter through a clear corneal wound.

Methods:
Retrospective, consecutive case series

Results:
A consecutive case series of 3 eyes from 3 patients with dislocated CTR-IOL-capsule complexes were included. CTRs were successfully explanted by freeing the eyelet of the CTR from the capsule, grasping it with the CTR-inserter hook, and retracting the CTR into the device's shaft while maintaining the entire IOL-CTR-capsule complex in a safe position behind the iris plane. No complications of the procedure were observed in any of the cases. All patients had concomitant IOL exchange via modified sutureless Yamane scleral fixation. The mean pre-operative Snellen visual acuity improved from 20/232 to a mean post-operative Snellen acuity of 20/56 (p value = 0.037, student's t-test) at a minimum of four months of follow-up.

Conclusion:
The CTR inserter provides a simple and efficient technique for CTR removal from IOL-CTR-capsular bag complexes dislocated into the vitreous cavity.

IRB APPROVAL No - exempt

Surgery Symposium 3
Impact of Delay in Repair of Rhegmatogenous Retinal Detachment: Real-World Outcomes from the IRIS Registry

- Sunir Garg, MD, FACS, FASRS
- Jeff Park, BHSc
- Lynn Liu, MS
- Charles Li, BA
- Flora Lum, MD
- Rahul Khurana, MD, FASRS
- Rajeev Muni, MD, MSC, FRCS(C), FASRS

Objective:
To determine the influence of delay in repairing fovea-on and fovea-off rhegmatogenous retinal detachments (RRD) on postoperative outcomes.

Purpose:
Timing of RRD repair is a topic of controversy. Generally, fovea-off RRD is repaired within one week of presentation, and fovea-on RRD is repaired within 24-hours. However, analysis of prospective longitudinal data suggests that a shorter time to surgery in fovea-off RRD may be beneficial for photoreceptor ellipsoid zone recovery. Additionally, the results of a recent UK database study suggests that patients with fovea-off RRD have better outcomes when surgery is performed within 72 hours of central vision loss. The purpose of this study is to assess the association of delay in repair of primary RRD with functional and anatomic outcomes in patients with fovea-on and fovea-off RRDs.

Methods:
This is an IRIS Registry retrospective cohort study of primary RRD cases (subclassified based on VA at presentation for fovea-on (≥20/40) and fovea-off (<20/200)) that underwent scleral buckle, pars plana vitrectomy (or combination), or pneumatic retinopexy, from 2015 to 2020. Eyes with no reported baseline visual acuity, unspecified laterality, and tractional detachments were excluded. The primary outcome was the mean postoperative VA in fovea-off patients repaired in <=3 days compared to 4-7 days and fovea-on patients repaired in <=1 day compared to >1 day of presentation. We also assessed outcomes in fovea-off patients repaired in <=3 days compared to >3 days of presentation.

Results:
A total of 125,503 eyes from 121,316 unique patients with a mean age of 60.3 (SD 12.8), consisting of 37% females were included in the analysis. Twenty-four percent of the eyes were pseudophakic. The single-operation anatomic reattachment rates were 86% and 84%, for the fovea-off (n= 16,827) and fovea-on RRDs (n= 36,865), respectively. The mean 1-year post-operative logMAR VA was significantly better for fovea-off RRDs undergoing repair within <=3 days compared to 4-7 days (0.58 [SD 0.53] vs 0.75 [SD 0.57], difference=0.17[RKM1] , p<0.001) and when surgery was performed in <=3 days compared to >3 days (0.58 [SD 0.53] and 0.83 [SD 0.59], difference= 0.25, p<0.001). [RKM2] Furthermore, 1-year mean postoperative VA was better for fovea-on RRDs undergoing surgery within <= 1 day compared to >1 day (0.31 [SD 0.39] and 0.36 [SD 0.43], difference=0.05 logMAR, p<0.001). These differences between groups all remained statistically significant after adjusting for baseline vision, age, sex, ethnicity, smoking status, insurance status, and procedure type (all p's < 0.0001). The adjusted odds of achieving a single procedure anatomic reattachment at 12 months was 1.16 (95% CI=1.04-1.30) for macula-off cases undergoing repair within <=3 days compared to 4-7 days (p=0.009) and 1.09 (95% CI=1.01-1.17) for macula-on cases undergoing repair within <=1 day compared to >1 days (p=0.018).

Conclusion:

This large retrospective cohort study utilizing the IRIS Registry suggests that better visual acuity and anatomic outcomes are achieved for fovea-off RRDs with repair in <=3 days compared to 4-7 days after presentation and for fovea-on RRDs within <=1 day compared to >1 day of presentation.

IRB APPROVAL Yes

Surgery Symposium 3

Timing of Delayed Retinal Pathology in Patients Presenting With Acute Posterior Vitreous Detachment in the IRIS Registry

- Gautam Vangipuram, MD
- Charles Li, BA
- Linda Harrison, PhD
- Flora Lum, MD
- Gaurav Shah, MD

Objective:

To determine the appropriate reexamination time frame in eyes presenting with a retinal break or detachment after initial posterior vitreous detachment (PVD).

Purpose:

Posterior vitreous detachment (PVD) is a common ocular pathology presenting to both general ophthalmology and retina clinics. Due to the dynamic nature of a PVD, retinal pathology may develop after the initial exam. Therefore, the timing of repeat evaluation following a symptomatic PVD is important. The purpose of this study was to determine the incidence and timing of delayed retinal pathology following a PVD in a large generalized population as well as ocular risk factors that may predispose patients to develop retinal pathology either sooner or more frequently following a PVD.

Methods:

This was a non-randomized retrospective cohort study using the American Academy of Ophtalmology (AAO) IRIS® registry. Patients coded to have an acute symptomatic PVD from 2013 to 2018 were included with at least one year of follow up. Eyes were further stratified into those with no ICD code for retinal break or detachment on the date of PVD (subcohort A) vs. eyes with a retinal break or detachment on the date of PVD (subcohort B). The primary outcome was time (days) to a delayed break or detachment following an initial PVD. A multivariable frailty survival model was conducted on baseline co-variates in predicating a delayed retinal break or detachment with significance set to $P < .05$.

Results:

A total of 441,517 eyes were included as part of subcohort A and 33,141 eyes comprised subcohort B. A total of 10,454 (2.36%) eyes in subcohort A went to develop a delayed retinal break (n= 7,186, 1.62%) or detachment (n= 4,147, 0.94%) within 1 year of the initial PVD. The median time to delayed retinal break or detachment in this cohort was 38 and 46 days, respectively in eyes examined by a retina specialist vs. 38 and 57 days, respectively in eyes examined by a non-retina specialist. Of eyes included in subcohort B, 23,922 (72.2%) went on to develop another retinal break (n=17,100, 51.5%) or retinal detachment (n=9,479, 28.6%). The median time to delayed retinal break or detachment in this cohort was 14 and 5 days, respectively in eyes examined by a retina specialist vs. 20 and 7 days respectively in eyes examined by a non-retina specialist. Eyes with vitreous hemorrhage (HR 10.2 [9.25-11.2 95% CI]), lattice degeneration (HR 3.77 [3.37-4.20 95% CI]) and myopia (HR 1.45 [1.34-1.56 95% CI]) were found to be at a higher risk of developing delayed break or detachment. Of these "high-risk" eyes, 3,016 (4.89%) were observed to present with delayed retinal break or detachment following initial PVD in subcohort A. The median time to break (n=2197, 72.8%) or detachment (n=1127, 37.3%) in this subcohort was 24 and 29 days, respectively.

Conclusion:

Follow up examination after initial PVD is necessary to diagnose delayed retinal breaks. Repeat examination should take place at least once within six weeks after initial PVD for all eyes, and strong consideration for within one month for eyes with higher risk features.
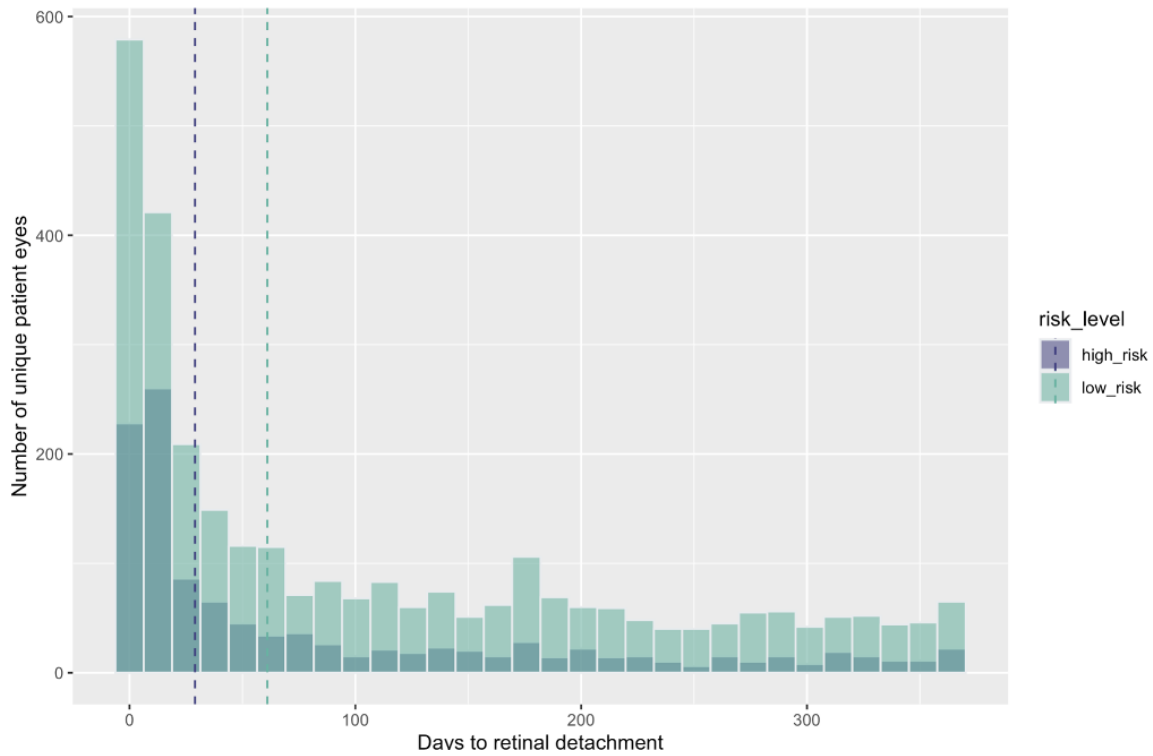
IRB APPROVAL No - no IRB or exemption
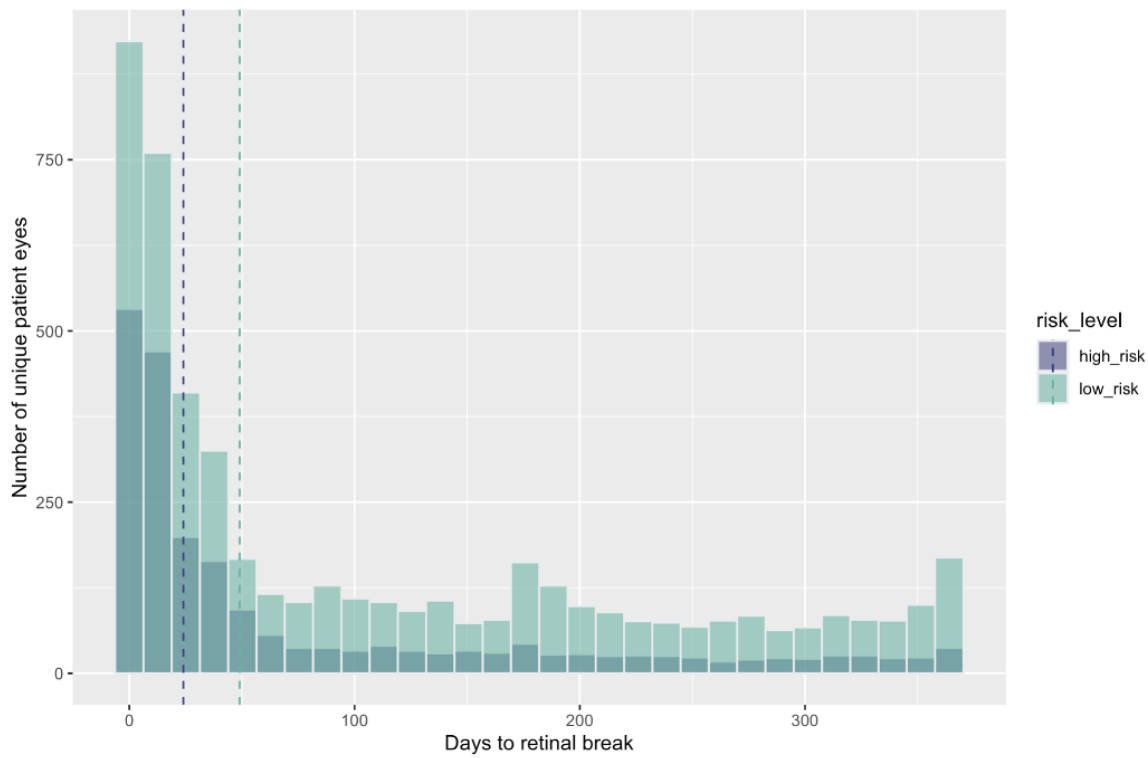
Days to delayed retinal break

Days to delayed retinal detachment

Surgery Symposium 3
Incidence and Risk Factors for Rhegmatogenous Retinal Detachment After Cataract Surgery: Analysis of the American Academy of Ophthalmology IRIS Registry

- M. Ali Khan, MD, FACS, FASRS
- Michael Morano, MD
- Colleen Halfpenny, MD
- Douglas Wisner, MD
- Qiang Zhang, PhD
- James Sharpe, MS
- Leslie Hyman, PhD
- Allen Ho, MD FASRS

Objective:
To determine the incidence and risk factors for rhegmatogenous retinal detachment (RRD) following cataract surgery in the United States.

Purpose:
To estimate the frequency of RRD within one year post cataract surgery, evaluate demographic and ocular risk factors for RRD, and compare differences in the rates of RRD between uncomplicated and complicated cataract procedures.

Methods:
Retrospective, cohort analysis of the IRIS Registry was performed. Eyes of patients aged 40 years or older undergoing cataract surgery from 2014-2017 were included. Eyes with history of RRD or RT were excluded. Incidence of RRD, as identified using relevant CPT codes, within one year after cataract surgery was the primary outcome. Multivariable logistic regression was used to evaluate risk factors for RRD after cataract surgery, including demographic features (age, sex, race, ethnicity), ocular comorbidities (lattice degeneration, posterior vitreous detachment (PVD), high myopia), and intraoperative factors (hypermature cataract, pseudoexfoliation, floppy iris syndrome, complex surgery CPT code).

Results:
Of 3,177,195 eligible eyes (1,983,712 patients), RRD occurred in 6,690 (0.21%) within one year after cataract surgery. Logistic regression odds ratios (OR) showed increased risk of RRD (OR=3.15; 95% CI=2.99-3.12; P<0.05) for males versus females. Risk was higher in younger patients compared to patients over age 70, peaking at age 40-50 for RRD (OR=8.61; 95% CI=7.74-9.58; P<0.05). RRD risk increased in eyes with lattice degeneration (OR=10.53; 95% CI=9.82-11.28; P<0.05), high myopia (OR=1.2; 95% CI=1.14-1.27; P<0.05), and eyes with PVD (OR=1.24; 95% CI=1.15-1.34; P<0.05). Presence of a hypermature cataract (OR=1.61; 95% CI=1.06-2.45; P<0.05) and use of the complex surgery CPT code (OR=1.52; 95% CI=1.4-1.66; P<0.05) also increased RRD risk.

Conclusion:
Analysis of the IRIS registry revealed RRD incidence is low (0.21%) within one year after cataract surgery in the current era of phacoemulsification technology. Lattice degeneration, male sex, younger age, PVD, high myopia, hypermature cataract, and use of the complex cataract CPT code conferred increased risk for RRD. These data from a large, national database may aid in pre-operative counseling of prospective cataract surgery patients.

IRB APPROVAL No - no IRB or exemption

Surgery Symposium 3

Two-Year Evaluation of Subretinal Fluid Drainage Techniques in Pars Plana Vitrectomy for Primary Rhegmatogenous Retinal Detachment (ELLIPSOID-2 Study)

- Bryon McKay, MD, PhD, FRCSC
- Aditya Bansal, MD
- Michael Kryshtalskyj, MD
- David Wong, MD, FRCS(C), FASRS
- Alan Berger, MD, FRCS(C), B Sc
- Rajeev Muni, MD, MSC, FRCS(C), FASRS

Objective:
Does drainage of subretinal fluid through a pre-existing retinal break improve visual and functional outcomes compared to PFCL for uncomplicated macula off rhegmatogenous retinal detachments at 2 years post op?

Purpose:
To compare visual acuity, complications, and photoreceptor integrity following pars plana vitrectomy (PPV) with subretinal fluid (SRF) drainage from the peripheral retinal breaks (PRB) vs. posterior retinotomy (PR) vs. perfluorocarbon liquid (PFCL) for rhegmatogenous retinal detachment (RRD) at 2 years post-surgery

Methods:
Retrospective analysis of 300 eyes (300 patients) with primary uncomplicated RRD that underwent PPV (100 consecutive patients included in each group), 2-year extension from the ELLIPSOID study. Primary outcomes were visual acuity (BCVA) and complications (cystoid macular edema (CME), epiretinal membrane (ERM)). Secondary outcomes were discontinuity of the external limiting membrane (ELM), ellipsoid zone (EZ) and interdigitation zone (IDZ) on spectral-domain optical coherence tomography (SD-OCT) at 2-year post-surgery.

Results:
Proportion of patients with visual acuity assessment and gradable SD-OCT at 2-years was similar between group (PRB 91%, PR 86%, PFCL 87%). There were no significant differences in age, sex, baseline visual acuity, lens status, extent of RRD and time from macula-off to presentation. Single-operation reattachment rate at 24 months was similar between groups (PRB 86%; PR 85%; PFCL 83%, p=0.9). Mean(±SD) logMAR BCVA at 24 months was significantly better in the PRB compared to PR and PFCL, with PFCL having the worst BCVA (PRB 0.5±0.6; PR 0.7±0.5; PFCL 0.9±0.7, p=0.001). Rate of CME was significantly higher with PFCL (PRB 29.7%; PR 30.2%; PFCL 45.9%, p=0.0015) and ERM formation was significantly higher in PR (PRB 62.6%; PR 93.0%; PFCL 68.9%, p=0.002) compared to the other groups. There were no differences in ELM or EZ discontinuity on the 3-mm foveal scans. However, discontinuity of the IDZ was significantly higher in the PFCL group (PRB 34%; PR 27%; PFCL 46%, p=0.002) on the 3-mm foveal scans at 24 months.

Conclusion:
Visual acuity at 2-years was inferior in eyes with PFCL compared with drainage from the PRB or PR for primary uncomplicated RRD. Drainage via PRB demonstrated the best visual acuity recovery. There was a corresponding greater risk of discontinuity of the IDZ in PFCL cases, and a greater risk of CME with PFCL and greater ERM with PR. Drainage technique may impact long-term visual acuity results and photoreceptor integrity.

IRB APPROVAL Yes