Conclusions: Stepped strabismus surgery is a useful technique for borderline cases with the potential for reducing the number of extra ocular muscles operated on without compromising the surgical outcome.

019 Incidence of symptomatic torsional and vertical diplopia after superior rectus transposition for esotropic duane syndrome and 6th nerve palsy. Anna G. Escuder, Melanie A. Kazlas, Gena Heidary, David G. Hunter, Linda R. Dagi

Introduction: To describe the incidence of symptomatic vertical and torsional strabismus after superior rectus transposition (SRT) for esotropic Duane syndrome (DS) and 6th nerve palsy.

Methods: Retrospective chart review of pre- and postoperative sensorimotor exams on patients with 6th nerve palsy or esotropic DS treated with SRT with or without medial rectus recession (2000-2018). Patients with bilateral SRT, or treatment with additional rectus or oblique surgery were excluded.

Results: 66 patients met inclusion criteria, including 32 patients with sixth nerve palsy and 34 patients with DS. Average follow up was 2.4 years and age at surgery, 22.8 years. Average preoperative esotropia was 42^{Δ} (95% CI, 38.5- 46.2) and postoperative was 10.2^{Δ} (95% CI, 7.76-12.7). Average pre- and postoperative vertical deviation in primary gaze was 1.78^{Δ} (95% CI, 0.95-2.62) and 2.62^{Δ} (95% CI, 1.48-3.63), respectively. Abduction enhancement was performed with SR-LR loop myopexy in 47 and scleral-fixated myopexy in 7 patients. Symptomatic vertical diplopia occurred in 4 of 47 treated with loop myopexy and in 1 of 7 with scleral-fixated. None of the 66 patients developed symptomatic torsion.

Discussion: Superior rectus transposition has been advocated as an alternative to balanced vertical rectus transposition. In this largest-to-date retrospective review, 7.5% of patients developed symptomatic vertical diplopia and none developed symptomatic torsional diplopia.

Conclusions: Superior rectus transposition with or without medial rectus recession provides a muscle-sparing alternative to balanced vertical rectus transposition with similar rates of induced vertical and torsional diplopia.

020 Home tonometry redefines glaucoma drainage device management in childhood glaucoma. Michelle S. Go, Navajyoti R. Barman, Robert J. House, Sharon F. Freedman

Introduction: The postoperative management of the nonvalved Baerveldt glaucoma drainage device (GDD) presents challenges in children due to widely variable intraocular pressure (IOP) often occurring perioperatively. We evaluated the use of home tonometry in the management of Baerveldt GDDs for refractory childhood glaucoma.

Methods: As part of an ongoing prospective study involving home rebound tonometry, the families of patients receiving Baerveldt GDDs were trained to use the Icare® rebound tonometer (Ta01,Finland,Oy) and asked to document IOP, relevant symptoms, and medication changes onto a web-based data application or Excel spreadsheet. Data were analyzed for time to tube opening, multiple-day fluctuations, and various IOP trends. Clinician response to IOP fluctuations detected by home tonometry was also evaluated.

Results: Included were 19 patients (mean age, 16.1 ± 9.6 years) having Baerveldt implantation from 2015-2018 by one attending. Home tonometry detected 100% (12/12) of spontaneous tube openings, which occurred at 6.0 ± 0.5 weeks. Mean IOP decreased 32.8% (25.1 vs 16.9 mm Hg; $P < 0.01$) and 5-day IOP fluctuation decreased from 14.5 to 6.2 mm Hg ($P < 0.05$) after tube opening. Preoperative, post-implantation, and post-opening IOP range was 11-59, 3-61, and 1-50 mm Hg, respectively. Home tonometry corroborated clinical hypotony in 5 eyes and early hypertensive phase in 9. It prompted 75 documented medication changes among 14 patients.

Discussion: Home rebound tonometry accurately detected tube opening and alarming IOP fluctuations, allowing clinicians to promptly and appropriately respond to these events.

Conclusions: Home tonometry-augmented GDD management in childhood glaucoma may improve care of these challenging patients.

021 High prevalence of sagging eye syndrome in adults with binocular diplopia. Toshiaki T. Goseki, Suh Soh Youn, Laura Robbins, Stacy L. Pineles, Federico G. Velez, Joseph L. Demer

Introduction: Sagging eye syndrome (SES), horizontal and/or vertical strabismus caused by orbital connective tissue degeneration, was first defined 10 years ago. While SES is increasingly recognized as a cause of acquired diplopia, its prevalence is unknown. We investigated SES prevalence in diplopic adults.

Methods: We reviewed all new adults over age 40 years, presenting to the UCLA strabismus division with binocular diplopia between August 2017 and September 2018. Age, gender, and type of strabismus were analyzed.

Results: We reviewed 208 total patients of mean $\pm$ SD age 67 ± 11 (range, 40-91) years of whom 113 (54%) were female. The most common cause of diplopia was SES (28.8%), followed by exotropia (10.1%), thyroid ophthalmopathy (8.2%), trochlear palsy (8.2%), abducens palsy (7.7%), decompensated esophoria (4.8%), orbital trauma (3.4%), scleral buckling (2.9%), and skew deviation (2.4%). The 63 patients with SES were older at 71 ± 9 years (range, 52-91 years, $P < 0.0001$) and more predominantly female at 63% than other patients (49%, $P = 0.02$). SES caused 15% of all diplopia in patients from ages 50-59 years, 33% from ages 60-69 years, 37% from ages 70-79 years, and 33% over age 79 years, but no diplopia under age 50 years.

Discussion: SES is the most common cause of acquired binocular diplopia in adults over 50 years old, comprising about 30% of all cases, easily surpassing cranial neuropathies and thyroid eye disease. However, SES was not encountered in patients under age 50 years.

Conclusions: It is important to recognize that SES is a very common cause of adult binocular diplopia.

022 Deep learning for monitoring rop progression. Kishan Gupta, Stanford Taylor, J. Peter Campbell, Jayashree Kalpathy-Cramer, James M. Brown, R. V. Paul Chan, Sang J. Kim, Michael F. Chiang

Introduction: To evaluate the clinical utility of quantitative image analysis using a deep learning plus disease severity score to monitor disease progression and response to treatment in patients with retinopathy of prematurity (ROP).

Methods: Images from clinical exams performed between July 2011 and December 2016 of infants in the multicenter Imaging and Informatics in ROP study were reviewed to identify babies with treatment-requiring disease, and scored by an automated deep learning algorithm with from 1 (normal retinal vasculature) to 9 (severe plus disease). Severity scores for treated and untreated eyes were compared longitudinally. The 4-week pre- and post-treatment scores with either laser or anti-vascular endothelial growth factor (anti-VEGF) were assessed.

Results: A total of 1692 eyes were analyzed. 91 eyes progressed to treatment-requiring disease. Mean severity scores of the two groups

significantly differed at all time points analyzed but became more apparent with advancing post-menstrual age (PMA). At 36-38 weeks PMA, mean score for treatment-requiring disease was 5.2 compared to 1.2 in untreated eyes ($P < 0.01$). 47 eyes received laser (n = 39) or anti-VEGF therapy (n = 8). The mean severity score 2 weeks pre-treatment (4.2) and post-treatment (4.0) significantly differed from treatment time (7.4, $P < 0.0001$ for each).

Discussion: The ROP severity score correlates with clinical progression and response to treatment. The score was an independent predictor of progression to treatment-requiring disease. The score at time of treatment was an independent predictor of disease recurrence.

Conclusions: Automated computer-based image analysis may be considered as a means to monitor disease progression and treatment response in infants undergoing screening for ROP.

023 Treating central-peripheral rivalry (CPR)-type diplopia. Jonathan M. Holmes, Sarah R. Hatt, David A. Leske, Raymond Iezzi

Introduction: Epiretinal membranes (ERM), and other maculopathies associated with abnormalities of the photoreceptor mosaic, may cause central-peripheral rivalry (CPR)-type diplopia (aka dragged-fovea diplopia, binocular retinal diplopia). CPR-type diplopia is notoriously difficult to treat. We evaluated the success of various treatments.

Methods: Fifty patients (44 with ERM) undergoing treatment for CPR-type diplopia (101 treatment episodes) were included. We only included patients with 'sometimes' or worse diplopia for distance or reading, using the Diplopia Questionnaire. We evaluated: prism, Bangerter filter/tape, iseikonic treatment, and ERM peeling. We defined success as improvement in diplopia to 'never' or 'rarely' for distance and reading, at a 6-month follow-up examination. Failure was assigned if diplopia was 'sometimes' or more at follow-up or if in-office treatment failed (persistent diplopia or not tolerated). Each treatment episode was assigned an outcome (not all patients tried every treatment) and success rates calculated with 95% confidence intervals (CIs).

Results: Success was achieved in 4/7 (57%; 95% CI, 18%-90%) using Fresnel prism and 4/28 (14%; 4%-33%) using Bangerter/tape. 8/18 (44%; 22%-69%) had successful resolution of diplopia following ERM peeling (with or without prism). There was one success with iseikonic treatment (1/23; 5%, 0%-22%) but none using loose or ground prism (0/25; 0%, 0%-14%).

Discussion: Fresnel prism treatment was somewhat more successful than expected (presumably by blur) and Bangerter/tape treatment less successful. Unexpectedly, ERM peeling improved CPR-type diplopia in many patients.

Conclusions: CPR-type diplopia may be amenable to treatment by ERM peel, Fresnel prism, or blur and each should be considered for such patients.

024 Machine learning for prediction of pediatric ophthalmology examination lengths and scheduling optimization. Michelle R. Hribar, Wei-Chun Lin, Isaac H. Goldstein, Michael F. Chiang

Introduction: Pediatric ophthalmologists are under pressure to see more patients in less time. This study investigates a machine learning model for predicting exam length in pediatric ophthalmology, based on existing electronic health record (EHR) data.

Methods: Data from 3049 office visits (2015-2018) from five pediatric ophthalmologists were used in a random forest machine learning classification model with 12 features (including prior average exam time, ICD-10 diagnosis code, age, dilation of eyes, patient's language, clinic volume, hour of the office visit). The exam time was predicted to be: short (shortest 20% of exam lengths), medium (middle 60%), or long (longest 20%). Ophthalmologists predicted exam lengths before scheduling each patient based on clinical and social factors. Accuracy was determined by comparing predictions to the actual exam lengths.

Results: The classification model had 65% accuracy for predicting exam length (short vs medium vs long) while the providers' accuracy was 41%. In the machine learning model, the top five predictors of exam length based on mean decrease accuracy (MDA) were prior average exam length, dilation, ICD-10 code, ophthalmologist, and patient age.

Discussion: This study demonstrates that existing EHR data may be used in machine learning algorithms to predict patient exam lengths. We have previously shown using computer-based simulations that scheduling patients according to their exam lengths (shortest exams first) reduced patient wait times. Taken together, this has potential to improve clinical efficiency for pediatric ophthalmologists.

Conclusions: Machine learning methods can predict patient exam lengths with comparable or better accuracy than physicians.

025 Diagnosis of congenital special forms of strabismus based on high-throughput sequencing and high-resolution MRI. Yonghong Jiao, Hongyan Jia, Yi Liang, Yulan Liang, Qinglin Chang, Hui Wang

Introduction: Congenital special forms of strabismus (CSS) are a group of clinically and genetically heterogeneous diseases, which are considered to be neuropathic or myopathic. We aim to establish an effective diagnosis workflow for CSS by utilizing and combining exonic sequencing and MRI.

Methods: 61 families with CSS were enrolled in the study. 22 were familial and 39 were sporadic. All patients underwent comprehensive ophthalmic examinations and MRI. 115 candidate genes have been captured and sequenced, which may be associated with congenital cranial dysinnervation disorder (CCDDs), congenital ptosis, ophthalmoplegia, congenital myopathy and congenital muscular dystrophies (CMD). After excluding mutations in the 115 candidate genes in 22 probands, we conducted whole-exome sequencing (WES).

Results: MRI examinations of 61 patients showed marked hypoplasia cranial nerve and/or extraocular muscles. 9 mutations in 5 genes (*KIF21A*, 45.9%; *TUBB3*, 13.2%; *POMGNT1*, 1.6%; *RYR1*, 1.6%; *CHN1*, 1.6%) from 39 patients (63.9%) were identified. Out of 39 patients, 27 were diagnosed with congenital fibrosis of extraocular muscles (CFEOM), 2 patients were diagnosed with muscle-eye-brain disease (MEB), 2 patients diagnosed with familial Duane syndrome and 1 patient diagnosed with CMD. 4 patients with potentially pathogenic variants were identified with WES.

Discussion: Since CSS usually have overlapping clinical features, accurate diagnosis of CSS-related diseases is challenging. Combining MRI with exonic sequencing, the diagnosis rate could increase effectively.

Conclusions: We established a high sensitivity and specificity diagnosis workflow for CSS, based on MRI and targeted exonic sequencing, which could be a rapid, cost-efficient diagnostic option for clinicians to utilize.

026 What causes slow binocular reading in amblyopic children? Krista R. Kelly, Reed M. Jost, Bryan De La Cruz, Jeffrey S. Hunter, Lori Dao, Cynthia L. Beauchamp, Joel N. Leffler, Becky Luu, Eileen E. Birch