

new loupe design on surgeons' posture, we utilized kinematic motion capture, musculoskeletal modeling and electromyography (EMG).

Methods: We customized a Galilean loupe through 3 D printing. It was lighter than conventional designs, had a large angle of declination, and was fitted with a novel head strap that reduced loupe slippage and offloaded weight from the nasal bridge. We compared the redesigned loupe to a conventional loupe by quantifying the force on the nasal bridge, operating neck flexion, and neck muscle effort and activity by using material properties, a bubble inclinometer, computational modeling, and EMG, respectively.

Results: Results are presented as conventional loupe vs redesigned loupe. Loupes' forces on the nasal bridge were calculated as 0.648 N vs 0.272 N. Operating neck flexion angles were 40° vs 15°. From the computational model, the counter torques needed to maintain the neck at the loupes' operating postures were 1537 Nmm vs. 933 Nmm. Upper trapezius EMG activity was found to be 0.521 ± 0.047 vs 0.150 ± 0.037 (% of maximal voluntary muscle contraction).

Discussion: The reduction in nasal bridge force, operating neck flexion, and neck muscle effort and activity indicate that using a lighter Galilean loupe, with a high angle of declination and an offloading head strap, has the potential to reduce neck muscle loading in surgeons.

Conclusions: New designs of surgical loupes may reduce the risk of musculoskeletal disorders of the neck and lower back of ophthalmologists, by improving the surgeons' ergonomics.

034 Optical coherence tomography guided localization and laser photocoagulation of invisible new retinoblastoma. Sameh E.

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Introduction: Invisible retinoblastoma tumors are now detected by prenatal identification of *RB1* pathogenic variants inherited from affected parents, followed by early delivery with screening for retinal tumors using handheld optical coherence tomography (OCT). Laser photocoagulation is challenging, requiring exact localization of an invisible tumor. We describe an OCT-guided localization and photocoagulation technique and its preliminary outcome.

Methods: OCT revealed round homogeneous invisible tumors within the inner nuclear layer. Software calipers placed beside anatomical retinal landmarks (branched/curved vessels, fovea or optic disk) mapped the tumor location and extent. A single laser (532 nm) burn flagged the location and OCT evaluated the tumor-laser burn relationship; laser treatment was then continued in the correct location. Post-laser OCT ensured complete treatment. This technique was used to treat 11 new invisible posterior pole tumors in 7 eyes of 5 children.

Results: Localization and tumor-laser burn relationships were 100% accurate. All showed swelling and hyper-reflectiveness in post-laser OCT. A maximum of 2 photocoagulation sessions (2 weeks apart) were sufficient to successfully manage 10/11 (91%) tumors with resulting permanent scars. Two tumors (18%) developed OCT-detected subclinical recurrences within 4 months, each treated by one laser session. No treatment scar showed migration, foveal involvement or retinal traction at 1 year follow-up.

Discussion: Precise localization avoided misapplied laser burns, preserving normal retina resulting in small treatment scars with less treatment burden and a good visual outcome (no foveal involvement by tumor/laser).

Conclusions: OCT-guided localization and photocoagulation technique is valuable in achieving precision results in managing invisible new retinoblastoma tumors.

035 Determining the tractional forces on vitreoretinal interface using computer simulation and animal models to elucidate the retinal hemorrhage patterns in abusive head trauma. Donny W. Suh

Introduction: Pathophysiology of the retinal findings in abusive head trauma (AHT) is not clearly understood, but the role of vitreoretinal traction has been hypothesized. Combining computer simulation (CS) and animal models, we test the hypothesis that vitreo-retinal traction during forcible shaking can exceed the vitreo-retinal adhesion.

Methods: CS model of pediatric eye was developed to determine stresses on various layers of retina and its vessels during shaking. To provide empirical context surrounding the computationally predicted stresses, young sheep eyes (n = 7) were harvested at 6 months of age. A 5x5 mm sclerotomy was created, and the underlying retina exposed. Polytetrafluoroethylene patch was attached to the subretinal surface and then pulled to measure the stress required to create vitreoretinal separation.

Results: Stress values from the CS ranged from 3 to 16 kilopascal (kPa). Maximal stress was observed at the peripheral retina, retinal vessel bifurcations, and the posterior pole. Stress values were similar in preretinal, intraretinal, and subretinal layers. Stresses predicted by the computer simulations exceeded those measured in the ex vivo animal eye model, which showed stress values of 2–5 kPa.

Discussion: Ocular manifestations from abusive head trauma reveal unique retinal characteristics. Our model predicted stress patterns consistent with the diffuse retinal hemorrhages (RH) typically found in the posterior pole and around the peripheral retina in AHT. Our computer model demonstrated that similar stress forces were produced in different layers of the retina, consistent with the finding that retinal hemorrhages are often found in multiple layers of the retina. The computer model predicted that intraocular forces attained during forcible shaking of an eye can exceed the minimum threshold needed to produce vitreoretinal separation as measured in ex vivo sheep eyes. These data also support the theory that vitreous traction at the retinal surface is an important contributor to retinal hemorrhages and retinoschisis in AHT.

Conclusions: CS demonstrated that similar stress forces were produced in all three layers of the retina, consistent with the clinical findings that pan-retinal hemorrhages. Also, CS demonstrated that forces generated during shaking can potentially exceed the minimum threshold needed to produce vitreoretinal separation as measured in ex vivo sheep eyes. Our data support the theory that vitreous traction at the retinal surface may be an important contributing factor to retinal findings in AHT.

036 Diagnosis of inherited retinal degenerations in pediatric patients using the RETeval handheld electroretinogram. Cole J.

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Introduction: To investigate practicality and utility of the RETeval handheld electroretinogram (ERG) in the diagnosis of inherited retinal degenerations (IRD) in pediatric patients.

Methods: Electronic medical records of pediatric patients who received RETeval ERG testing at our institution were searched for patient demographic information, ophthalmic diagnoses, ocular exam data, and ERG results. Patients were stratified based on ophthalmic diagnosis and the presence of abnormal RETeval photopic and/or scotopic waveforms.

Results: In total, 64 pediatric patients with an average age of 6.7 years (median, 5.63 years; range, 2.86 months to 16.9 years) received 71 RETeval ERG's. 68 (96%) were performed without sedation. Among

21 patients with IRDs (7 genetically confirmed, 11 clinically diagnosed, and 3 suspicious retinal dystrophies), 18 (86%) had abnormal photopic waveforms. Of the three normal photopic results, two were in the suspicious category, and one had a known rod-cone dystrophy. 20 patients presumed to have an IRD based on clinical findings completed dark adapted testing, and 100% had abnormal scotopic waveforms.

Discussion: Our results show that the RETeval handheld ERG is a practical and accurate tool for early diagnosis of pediatric IRD's, often avoiding the need for sedation and operating room time with conventional corneal electrode ERG testing.

Conclusions: To our knowledge, this is the first study investigating both scotopic and photopic responses obtained with the handheld RETeval ERG in a cohort of pediatric IRD patients. This device is especially useful in younger children and may allow for widespread use of ERG's outside the tertiary care setting.

037 Feasibility of eye patch assistant plus a microsensor to monitor objective adherence with patching.

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Introduction: A microsensor was suggested to monitor adherence with patching amblyopia treatment due to its advantages: small, waterproof, long-lasting battery. However, its application has been limited because of a number of practical challenges: (1) it is so small that it is hard to hold and is easily lost; (2) children or pets may swallow it due to its candylike appearance. To overcome these challenges, we designed a small device, the Eye Patch Assistant (EPA), to facilitate patching with a microsensor. This study reports pilot data for use of the EPA coupled with a microsensor to monitor patching adherence.

Methods: Thirteen adults (11 control, 2 amblyopic) and 20 children (6 control, 14 amblyopic) were enrolled. Participants were asked to wear an Ortopad eyepatch (patch) or an Ortopad eyepatch plus the EPA with a microsensor embedded (patch+EPA). Each adult completed both testing conditions for 2 hours each in random order and reported their wearing time (based on clock). Each child was randomized to either Patch or Patch+EPA for a short period of time (5-20 min). The sensor reading interval was set to 5 min. After each test condition, a questionnaire with 12 questions related to comfort was administered.

Results: In the adult group, self-reported time wearing patch+EPA (mean \pm SD) was 119 ± 4 min, while the microsensor-reported 121 ± 6 min. In the child group, self-reported time wearing Patch+EPA was 9.4 ± 5.4 min, while the microsensor-reported 8.5 ± 5.3 min. There was no significant difference between self-reported and microsensor-reported patch-wear time (paired *t* test, *P* = 0.5). There was no significant in comfort scores (*P* > 0.05) for all questions.

Discussion: Objective adherence with patching can be monitored safely with a microsensor assisted with the EPA.

Conclusions: Within a predictable variability due to its 5 min sampling interval, a microsensor embedded in the EPA device provides a promising way to safely monitor adherence with patching in children.

038 Are piggyback IOLs recommendable for children? M. Edward Wilson, Rupal H. Trivedi

Introduction: The selective use of piggyback IOLs for young children has been reported since the mid-1990s but only in small numbers and without longer term follow-up. Surgeons currently have insufficient information about whether these techniques are recommendable.

Methods: An IRB-approved retrospective chart review was conducted of consecutive cases of piggyback IOL implantation in children at one institution.

Results: Fifty-one eyes of 40 children received piggyback IOL implantation, 42 eyes at the time of cataract surgery and 9 eyes as a later secondary procedure. Median age at cataract surgery and piggyback IOL placement were 0.51 and 0.73 years respectively. Four eyes (8%) underwent unplanned piggyback IOL removal (1 each for IOL tilt, pupillary capture, pupillary block, and pupillary membrane). Forty-four eyes had >5 years' follow-up (median, 12.42 years of follow-up); 35/44 eyes had the piggyback IOL explanted in a planned manner at a median of 3.24 years after implantation. 9 eyes have still not had the piggyback IOL explanted after a median 11.6 years of follow-up. 9 eyes have needed IOP-lowering topical medications, and 1 eye has been operated for glaucoma.

Discussion: Planned sulcus IOL explantation was uncomplicated in our series. While early-unplanned complications required IOL removal in 4 eyes, late complications were not noted and glaucoma developed at predictable rates for this population.

Conclusions: Piggyback IOL placement in young children (1 in the bag and 1 in the sulcus) appears to have an acceptable safety profile. It allows the surgeon to aim for emmetropia at surgery and manage increasing myopia over time rather than decreasing hyperopia.

039 Horizontal and vertical eye movements after horizontal and vertical recti were detached from eyes in patients with nystagmus.

Dongsheng Yang, Ping Wang

Introduction: We usually believe that horizontal or vertical eye movements would be eliminated if horizontal or vertical recti were detached from the eye. However, we observed large horizontal or vertical eye movements after horizontal or vertical recti were detached from the eye. We will report the video-recorded eye movements.

Methods: The medial and lateral recti were surgically detached from insertions of the eyes during extra-ocular muscle (EOM) surgeries in 5 adult patients with infantile nystagmus syndrome. In another patient with acquired nystagmus, whose right superior rectus and inferior oblique were detached from her right eye, large (up to 20°) upward eye movements were also recorded. The amplitudes of the eye movements was estimated based on the distance of the movements.

Results: The amplitudes of the horizontal eye movements are about 25° \pm 5° after the the medial and lateral recti were detached and amplitude of upward eye movements were about 20° after the superior rectus and inferior oblique were detached.

Discussion: Large horizontal and vertical eye movements were recorded after horizontal and vertical EOM were detached. It indicates that vertical recti may involve in horizontal eye movements and horizontal recti may involve in vertical eye movements.

Conclusions: Activity of vertical recti during the horizontal eye movements may need to be investigated, and vice versa for vertical eye movements.

040 Punctate hyperreflective vitreous opacities visualized by handheld spectral domain optical coherence tomography in premature infants screened for retinopathy of prematurity.

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Introduction: Vitreous changes in retinopathy of prematurity (ROP) are poorly understood. The goal of this study was to characterize