10:00 AM Room 225-AB
P-16 Papers: Refraction & Ocular Structure
Moderators: Melissa D. Bailey, OD, PhD, FAAO, Christopher Clark, OD

10:00 AM. **FORWARD AND INWARD MOVEMENT OF THE CILIARY MUSCLE APEX WITH ACCOMMODATION IN ADULTS** (120629)

Trang Pham, Loraine Sinnott, PhD, Chiu-Yen Kao, PhD, Melissa D. Bailey, OD, PhD, FAAO, The Ohio State University College of Optometry

RESULTS: For the change from 0 to 4.0 D of accommodation, CMTMAX increased with accommodation by 81.2 ± 70.8 µm (51.9 to 109.0, $p < 0.00001$), and SSMAX decreased with accommodation by -165.9 ± 300.5 µm (-282.7 to -49.1, $p = 0.008$). For the change from 0 to 6.0 D of accommodation, CMTMAX increased with accommodation by 95.36 ± 72.0 µm (66.8 to 122.0, $p < 0.00001$), and SSMAX decreased with accommodation by -193.93 ± 213.25 µm (-273.3 to -114.3, $p = 0.0001$). Qualitatively, we noticed that very thin ciliary muscles had a much less prominent ciliary muscle apex, and example images will be presented.
PURPOSE: To measure the forward and inward movement of the ciliary muscle with 4.0 and 6.0 D of accommodative response in young adults.
METHODS: Subjects included 24 young adults with a mean ± SD age of 23.7 ± 1.9 years. Visante images of the ciliary muscle were captured when the PowerRefractor indicated that subjects were accommodating at 0, 4.0, or 6.0 D. The point of maximum thickness (CMTMAX) and the distance between the scleral spur and CMTMAX (SSMAX) was also measured. The mean, standard deviation, and 95% confidence intervals for the change in CMTMAX and SSMAX with accommodation from 0 to 4.0 D and 0 to 6.0 D were calculated.
CONCLUSIONS: Using Visante images of the ciliary muscle, we were able to detect significant inward movement of the ciliary muscle by monitoring thickening at CMTMAX as well as significant forward movement of the apex by monitoring the distance from the scleral spur to CMTMAX. There was, however, a range of inward and forward movement across subjects, and we noted subjective differences in the morphology of thicker and thinner muscles during contraction.
ADDITIONAL COMMENTS: NSF DMS 0811003, NIH KL2RR025754 and T35-EY007151

10:15 AM. **RETINAL CHANGES AND PERIPHERAL REFRACTION USING OPTICAL COHERENCE TOMOGRAPHY** (120623)

Christopher Clark, OD, Ben Konynenbelt, Ann E. Elsner, PhD, FAAO, Yuen Ping Toco Chui, BSc, MSc, FAAO, Indiana University School of Optometry School of Optometry, Dean A. VanNasdale, OD, PhD, FAAO, The Ohio State University College of Optometry

RESULTS: OCT curvature change was correlated to axial length ($p = 0.02$.) ONL thickness asymmetries between superior/inferior and nasal/temporal were similar to reported literature on photoreceptor packing densities. Superior retinal ONL was thinner on average than inferior ($p = 0.01$.) Nasal ONL was thicker than temporal retina (p =

0.036.) Peripheral refraction, peripheral axial length, and OCT retinal curvature changes were similar to reported literature. ONL thickness had a significant interaction with axial length ($p = 0.007$) with longer eyes having thicker ONL central and thinner ONL peripherally.

PURPOSE: Peripheral refractive error has been proposed to provide defocus signals that affect normal and abnormal emmetropization. This defocus signal is still detected by the eye in the absence of inner retinal ganglion cells, which would suggest the signaling cascade exists in the outer retina at the levels of the amacrine, photoreceptor, etc. The purpose of this study is to examine the interaction between refractive error, axial length, and changes in the retina structure with a focus on the outer retinal layers.

METHODS: 20 subjects right eyes were imaged for this study (age range: 22 to 34, refractive error: -6.50 to +2.00.) Thirty degree OCT (Spectralis, Heidleberg) images were collected in a radial pattern along with peripheral refraction (Grand Seiko) and peripheral axial length measurements (IOLmaster, Zeiss.) OCT images were segmented with custom softwareto determine the curvature of the retina, as well as thickness of the total retina, ONL, OPL, and INL. Lateral magnification and tilt effects were corrected. Statistics were performed using repeat measures ANOVA in SPSS (IBM.)

CONCLUSIONS: OCT offers a rapid technique to measure changes in the retinal structure and change in retinal curvature. Changes in the retinal shape are due to changes in axial length. Further work needs to be done to determine whether these changes in retinal thickness are due to retinal stretching, due to neural remodeling of photoreceptors from blur, or an influence on emmetropization.

10:30 AM. **RETINAL AND CHOROIDAL THICKNESS IN MYOPIC ANISOMETROPIA** (120484)

Stephen J. Vincent, PhD, Michael J. Collins, FAAO, Scott A. Read, BAppSc Optom, PhD, Leo G. Carney, PhD, DSc, FAAO, Queensland University of Technology

RESULTS: The mean absolute SEq anisometropia was 1.74 ± 0.95 D and the mean interocular difference in axial length was 0.58 ± 0.41 mm. There was a strong correlation between SEq anisometropia and the interocular difference in axial length ($r = 0.90$, $p < 0.001$). Measures of RT and ChT were highly correlated between the two observers ($r = 0.99$ and 0.97 respectively) and in close agreement (mean inter-observer difference: RT 1.3 ± 2.2 µm, ChT 1.5 ± 13.7 µm). There was no significant difference in RT between the more (218 ± 18 µm) and less myopic eyes (215 ± 18 µm) ($p > 0.05$). However, the mean subfoveal ChT was significantly thinner in the more myopic eye (252 ± 46 µm) compared to the fellow, less myopic eye (286 ± 58 µm) ($p < 0.001$). There was a moderate correlation between the interocular difference in ChT and the interocular difference in axial length ($r = -0.50$, $p < 0.01$).

PURPOSE: To examine the foveal retinal thickness (RT) and subfoveal choroidal thickness (ChT) between the fellow eyes of myopic anisometropes.

METHODS: Twenty-two young (mean age 23 ± 5 years), healthy myopic anisometropes ≥ 1 D spherical equivalent [SEq] anisometropia) without amblyopia or strabismus were recruited. Spectral domain optical coherence tomography (SD-OCT) was used to capture images of the retina and choroid. Customised software was used to register, align and average multiple foveal OCT B-Scan images from each subject in order to enhance image

quality. Two independent masked observers then manually determined the RT and ChT at the centre of the fovea from each SD-OCT image, which were then averaged. Axial length was measured using optical low coherence biometry during relaxed accommodation.
CONCLUSIONS: Foveal RT was similar between the fellow eyes of myopic anisometropes; however, the subfoveal choroid was significantly thinner in the more myopic (longer) eye of our anisometropic cohort. The interocular difference in ChT correlated with the magnitude of axial anisometropia.

10:45 AM. **APICAL CILIARY MUSCLE THICKNESS INCREASES IN HYPEROPIA** (120615)
Melissa D. Bailey, OD, PhD, FAAO, Chiu-Yen Kao, PhD, Mallory K. Kuchem, OD, MS, Andrew D. Pucker, OD, MS, FAAO, Loraine Sinnott, PhD, The Ohio State University College of Optometry

RESULTS: More myopic eyes had thicker ciliary muscles at CMT2 (children: B = -11.8, p = 0.0005, young adults B = -8.7, p = 0.008, and anisometropes: B = -22.0, p < 0.0001) and CMT3 (children: B = -7.9, p < 0.002, young adults B = -6.3, p = 0.02, and anisometropes: B = -16.7, p < 0.0001), as previously reported, in all three studies. For all three studies, more hyperopic eyes had thicker CMTMAXApical values (children: β; = 19.0, p < 0.0001, young adults β; = 4.8, p < 0.05, and anisometropes: β; = 11.7, p < 0.0001) and CMT1Apical values (children: β; = 15.2, p < 0.0001, young adults β; = 5.1, p = 0.03, and anisometropes: β; = 10.3, p < 0.0001).
PURPOSE: To look for evidence of accommodative workload affecting ciliary muscle dimensions by evaluating the relationship between apical ciliary muscle thickness and refractive error.
METHODS: Subjects included 270 children, 92 young adults, and 30 patients with anisometropia. Mean ± SD ages were 8.7 ± 1.5 years, 24.4 ± 4.8 years, and 28.1 ± 5.5 years, respectively. From Visante images of the ciliary muscle, thickness was measured at the point of maximum thickness (CMTMAX) and 1 mm (CMT1), 2 mm (CMT2), and 3 mm (CMT3) posterior to the scleral spur. The apical fibers at CMTMAX (CMTMAXApical) and CMT1 (CMT1Apical) were calculated by subtracting CMT2 values from CMTMAX and CMT1. Cycloplegic, spherical-equivalent refractive error was measured with the Grand Seiko autorefractor. Separate multilevel regression models were completed for each study and at each thickness measurement.
CONCLUSIONS: In all three studies, more myopic eyes had a thicker ciliary muscle in the posterior region where the longitudinal fibers primarily reside; however, in the apical region, hyperopes had thicker ciliary muscles. It has always been counterintuitive that hyperopes would have thinner ciliary muscles when they accommodate more often than others. These results suggest that only the apical region of the muscle may be affected by workload.
ADDITIONAL COMMENTS: NSF DMS 0811003, NIH Grant KL2RR025754, Prevent Blindness Ohio

11:00 AM. **CORNEAL BIOMECHANICAL PROPERTIES AND CHOROIDAL THICKNESS OF EMMETROPES AND HIGH MYOPES** (120284)

Yin Zhi Wong, BOptom (Hons), Andrew KC Lam, PhD, FAAO, The Hong Kong Polytechnic University School of Optometry

RESULTS: The mean±SD spherical equivalent refractive error (SER) and AL for the emmetropic and high myopic groups were 0.01±0.26D and -8.64±1.73D, 23.80± 0.87mm and 27.28±0.94mm, respectively. Emmetropic and high myopic groups had similar CT, ST and CRF (p> 0.05). However, the high myopic group had significantly lower CH (10.34±1.45mmHg) than emmetropic group (11.13±1.15mmHg). The ChT of high myopes were significantly thinner than emmetropes at subfoveal (207.69±48.09&microm vs 340.00±78.49&microm), 1mm nasal (173.63±53.29&microm vs 300.93±69.68&microm) and 1mm temporal (222.44±52.98&microm vs 347.29±74.87&microm). ChT and CH were inversely correlated with AL (p< 0.05), but only ChT significantly correlated to SER (p< 0.01). CH had positive correlation with ChT at all regions (p< 0.05). CH and CRF had strong correlation with CT and ST (p< 0.001).
PURPOSE: Choroidal thickness (ChT) always relates to pathological myopia whereas the role of corneal biomechanical properties in myopia is still unclear. This study is an attempt to evaluate the corneal biomechanical properties and ChT of emmetropes and high myopes.
METHODS: Fifty-six normal, age-gender matched young adults were recruited in emmetropic (n=28) and high myopic groups (n=28). Corneal hysteresis (CH) and corneal resistance factor (CRF) were obtained using Ocular Response Analyzer, corneal thickness (CT) and stromal thickness (ST) were evaluated using confocal microscope and axial length (AL) was measured using optical biometer. Thirty subjects (14 emmetropes, 16 high myopes) had ChT measured using enhanced depth imaging from spectral-domain optical coherence tomography. The horizontal cross-section of ChT at subfoveal, 1mm nasal and 1mm temporal to fovea were evaluated. Only one eye of each subject was studied.
CONCLUSIONS: CH might represent some biomechanical properties of the posterior ocular segment.
ADDITIONAL COMMENTS: Supported by the International Postgraduate Scholarships for PhD Studies and the Development of Niche Areas Funding on Myopia from PolyU.

11:30 AM. **SIMULTANEOUS IMAGING OF OCULAR ANTERIOR SEGMENT BIOMETRY AND CILIARY MUSCLE DURING ACCOMMODATION** (120580)
Yilei Shao, Izhu Tao, Jianhua Wang, MD, PhD, FAAO, Yufeng Ye, Bascom Palmer Eye Institute, Meixiao Shen, School of Ophthalmology and Optometry, Wenzhou Medical College

RESULTS: There were no differences in measured parameters between two sessions (P > 0.05). Compared with relaxed condition, the PD, ACD, ASC significantly decreased, while the LT increased when accommodating (P < 0.05). The thickness and area of anterior portion of the ciliary muscle increased and that of the posterior portion decreased (P < 0.05) during accommodation. The ASC was found negatively correlated with the

thickness and area of anterior portion of the ciliary muscle (r range: -0.42 to -0.47, $P < 0.05$).
PURPOSE: To investigate the relationship between the biometric dimensions of the ocular anterior segment and ciliary muscle during accommodation with spectral-domain optical coherence tomography (SD-OCT).
METHODS: A custom long scan depth (12.1 mm in air) SD-OCT was based on CMOS camera with a scanning speed of 70,000 A-lines/second. The light source was 840 nm center wavelength with the bandwidth of 50 nm. Image enhancement was done by overlapping two images acquired with two switchable reference arms, resulting in the placement of the zero-delay lines on the top and bottom of the two images. Another SD-OCT was used with the light source of 1310 nm center wavelength and 75 nm bandwidth. The two devices were synchronized for imaging the eye. The full range of the anterior segment at both horizontal and vertical meridians and the ciliary muscle were imaged at two separate sessions under relaxed and 4.00D accommodative states. After imaging correction, the pupil diameter (PD), anterior chamber depth (ACD), lens thickness (LT), radii of the anterior (ASC) and posterior (PSC) surface curvatures of the crystalline lens were obtained. The thickness and area of the ciliary muscle were calculated. Five left eyes from 5 subjects (age 34.8 ± 8.9 yrs) were enrolled.
CONCLUSIONS: The anterior segment biometry changed, and the ciliary muscle contracted during accommodation. The reshaping of the lens anterior surface was found related to the contraction of the ciliary muscle. The combined system of two SD-OCTs is a promising tool in studying accommodation.

11:45 AM. **SUBFOVEAL CHOROIDAL THICKNESS IN PEDIATRIC SUBJECTS** (120362)

Scott A. Read, BAppSc Optom, PhD, Stephen J. Vincent, PhD, Michael J. Collins, FAAO, Queensland University of Technology

RESULTS: Valid choroidal thickness measurements were possible in 39 out of 40 subjects (98%). Results from the two observers were highly correlated (r=0.99) and showed good agreement (mean difference between observers -0.6 ± 7.9 µm). The mean subfoveal choroidal thickness in the population was 355 ± 70 µm, ranging from 236 to 537 µm. Male subjects (n =22, mean 331 ± 66 µm) exhibited a significantly thinner choroid compared to female subjects (n = 17, mean 387 ± 64, $p = 0.01$). The mean axial length in the population was 23.0 ± 0.7 mm, which was significantly longer in males (mean 23.3 ± 0.7 mm) compared with females (mean 22.8 ± 0.8 mm, $p = 0.01$). A significant negative correlation was found between subfoveal choroidal thickness and axial length ($r = -0.404$, $p = 0.01$).
PURPOSE: To examine subfoveal choroidal thickness measurements and their relationship with gender and axial length in pediatric subjects.
METHODS: Forty children aged from 8 to 12 years (mean age 10 ± 1 years) had their subfoveal choroidal thickness derived from spectral domain optical coherence tomography (SD-OCT) images. The OCT measures from each subject utilized frame averaging to reduce speckle noise and enhance the visibility of the chorio-scleral interface. Two independent masked observers performed manual analysis of the SD-OCT images from each subject to determine subfoveal choroidal thickness. Measures of

axial length were also collected using optical low coherence biometry.
CONCLUSIONS: Reliable measures of choroidal thickness were possible with SD-OCT in the majority of pediatric subjects tested. Choroidal thickness in this sample showed relatively large inter-subject variations, but exhibited a significant correlation with axial length, with a thinner choroid being associated with a longer axial length. Significant differences in choroidal thickness were also found between genders which may relate to differences in axial length between males and females.
ADDITIONAL COMMENTS: Dr Scott Read was supported by an Australian Research Council Discovery Early Career Research Award.