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Special Lecture – Sek-Jin Chew Memorial Lecture

SL001

How animal studies can inform our understanding of myopia and emmetropisation

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Research on the causes of myopia has been mostly in two areas: epidemiological studies of humans and experimental studies of laboratory animals. I will discuss areas of potential overlap, where findings from animal work might inform research on humans and where findings on humans might provoke experimental exploration of the same topics in animals. In brief, I think that the recognition that homeostatic control of refractive error exists in animals has given credibility to similar views about human myopia that have existed for decades, if not centuries. Furthermore, the ability of the eyes of several species to compensate for the defocus imposed by either negative or positive lenses has raised the possibility that for humans as well, it is not blur *per se*, but hyperopic blur in particular that leads to myopia. This bi-directional homeostatic compensation of defocus raises several important questions: First, what visual cues guide the eye's growth? If we knew, for example, that longitudinal chromatic aberration or spherical aberration were important cues in a particular species, we would have reason to do the much more difficult investigations of these same signals in humans. Second, over what retinal area are these signals integrated? Might the pattern of refractive errors across the retina predict myopic progression? Third, how are the minute-by-minute alternations of myopic and hyperopic defocus across the retina integrated? In laboratory animals, how are episodes of wearing positive and negative lenses integrated to determine growth toward emmetropia? In humans, what are the temporal patterns of myopic and hyperopic defocus in the daily visual habits of children? More information on the human and animal sides of this question may lead to better predictions of which children are at risk to develop myopia, and perhaps to minimising the risk by manipulating the patterns of defocus experienced.

Plenary Lectures

PL001

Update of molecular genetic studies of severe myopia

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Purpose: The field of human myopia molecular genetics has expanded significantly in recent years. We now have information of several chromosomal loci identified both for moderate and severe myopia. For heritable high-grade nonsydromic myopia for instance, multiple autosomal dominant and X-linked loci have been determined. This presentation will summarise the findings to date of analytical approaches used.
Methods: Summary of mapping studies of myopia.
Results: Multiple chromosomal loci have been published for high-grade and moderate myopia using a variety of approaches.
Conclusion: Heritable high-grade myopia, as well as moderate myopia, appears to be common, complex disorder traits. Multiple approaches such as qualitative trait analysis, quantitative trait analysis of refractive error as well as refractive error components, twin study analysis of ocular biometric parameters, association studies, and longitudinal phenotype/genotype correlations are all necessary to identify implicated myopia susceptibility genes.

*Presenting Author

PL002

Peripheral vision and refractive development

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Purpose: Because of the prominence of central vision in primates, it has generally been assumed that foveal mechanisms dominate emmetropisation and that peripheral vision has little impact on refractive development. The purpose of this study was to determine whether peripheral vision could have a significant impact on ocular growth and emmetropisation.
Methods: The experimental subjects were 30 infant rhesus monkeys. All of the experimental rearing strategies were initiated at three weeks of age and refractive development was monitored by retinoscopy, keratometry, and A-scan ultrasonography. The effects of the following manipulations were investigated: (1) monocular foveal ablation combined with unrestricted visual experience, (2) monocular foveal ablation combined with recovery from binocular, experimentally induced refractive errors, (3) selective form deprivation of the peripheral retina, and (4) monocular foveal ablation combined with total form deprivation. Control data were obtained from 15 normal monkeys.

Results: Foveal ablations had no apparent effect on emmetropisation when infants were allowed unrestricted vision. As in normal monkeys, no systematic interocular differences in optical properties or axial dimensions were observed in the monkeys with monocular ablations. Similarly, foveal ablation did not affect the ability of the eye to respond to imposed optical defocus. Specifically, there were no interocular differences in the course of recovery in the monkeys that had binocular experimentally induced refractive errors and monocular foveal ablations. However, the subjects that experienced peripheral form deprivation and those that had foveal ablations combined with total form deprivation developed central axial myopias of -2.4 ± 2.3 D and -2.5 ± 2.0 D, respectively.

Conclusion: The peripheral retina can regulate emmetropisation and mediate vision-dependent alterations in refractive development. Moreover, an intact fovea is not essential for either emmetropisation or vision induced alterations in ocular growth.

Symposium Papers

S001

Study design considerations in complex diseases genetics

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Purpose: For decades, considerable effort was devoted to detect genetic loci contributing to the susceptibility of complex human diseases, but many genetic factors remain unknown. Concurrently, sophisticated statistical methods and high throughput molecular technologies are being developed - significantly impacting study design for conducting genetic studies of complex diseases. In this talk, I will review the study design and statistical methods for linkage and association studies.

*Methods:*The first step in planning a genetic study is to define a phenotype and investigate if it is genetic. Different analysis strategies require different sample types. For instance, linkage study requires family with multiple affected individuals, but association study can utilise unrelated case-control, parent-offspring triad, or discordant sibpairs. Current linkage programs assume markers in linkage equilibrium (LD). This assumption was valid for microsatellite markers, as they are more distantly spaced than single nucleotide polymorphism (SNPs). We have evaluated the effect of LD on linkage analysis through simulation studies. While linkage and association studies are the key features for gene mapping, we proposed a new approach, genomic convergence, which combines linkage, association, and gene expression results. As the whole genome SNP chips become available, many discussions on whole genome association (WGA) study have occurred. Both one and two-stage WGA designs will be addressed.

Results: As we prepared to use SNPs for linkage analysis, our study showed that the marker-marker LD inflates multipoint linkage results - especially for pedigrees with missing parental genotypes. The identification of glutathione S-transferase Omega 1 (GSTO1) for regulating the age-at-onset of Alzheimer and Parkinson diseases demonstrated the feasibility of genomic convergence.

Conclusion: Approaches to the mapping process should be outlined as complete as possible before the project begins. Some modification of study design is needed as we transfer from microsatellite markers to SNPs.

S002

Exploring the genetic basis of myopia - the genes in myopia (GEM) study

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Purpose: The Genes in Myopia (GEM) study was established to quantify the contribution of genes and environment in the development of refractive errors and ocular biometrics as well as identifying disease genes in myopia.

Methods: A total of 612 (345 MZ, 267 DZ) twin pairs with a mean age of 52 years were recruited through the Australian Twin Registry and participated in this study. In addition, 290 myopic probands (spherical equivalent worse than −0.50 D in both eyes) with a family history of myopia and 575 individuals from the proband's families were also recruited and examined. The mean age of subjects was 45 years with pedigrees containing between 3–38 family members with 2–18 myopic individuals. All individuals underwent a detailed eye examination including ocular biometric measurements using an IOL master, completed a risk factor questionnaire and had a blood sample taken.

Results: Intra-pair correlations for spherical equivalent and ocular biometrics were significantly higher in monozygotic or identical twin pairs compared with dizygotic or non-identical twin pairs ($p < 0.05$). In addition, heritability estimates ranged from 0.40–0.88 for spherical equivalent and 0.45–0.94 for axial length reflecting the different study designs inherent in family and twin studies. Heritability for anterior chamber depth was 0.28, and for corneal curvature was 0.29 in families. In twins an additive genetic effect accounted for a greater proportion of the variance in spherical equivalent whereas the variance in ocular biometrics, particularly axial length was explained mostly by dominant genetic effects.

Conclusion: The GEM study implicates genetic factors, both additive and dominant, as playing a significant role in refractive error (myopia and hypermetropia) as well as in ocular biometrics, particularly axial length. These results provide us with the confidence to undertake genetic linkage studies to identify myopia disease genes.

S003

A family-based test of association between alleles at the 5' UTR polymorphism of the myocilin (MYOC) gene and high myopia, in subjects from the UK

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Purpose: Mutations in the myocilin gene (MYOC) on chromosome 1 can cause juvenile-onset open-angle glaucoma and are associated with 2–4% of cases of primary open angle glaucoma in adults. Three previous studies have tested for association between MYOC polymorphisms and high myopia (all in subjects of Hong Kong or Singapore Chinese ethnicity). For a dinucleotide repeat polymorphism in the 5' UTR (untranslated region), two of these studies reported a significant association. For the four common alleles found by Wu et al. [1], the relative risk of high myopia increased from 0.7 to 4.3 as repeat length decreased. For the three alleles found by Tang et al. [2], highly myopic subjects showed an increased transmission from parents of the short (13-repeat) allele, and a decreased transmission of the long (15-repeat) allele. Leung et al. [3] found no significant association.

Methods: DNA was collected from a panel of 96 high myopes (6.00 D in both eyes) and both parents (all White European ethnicity). The dinucleotides repeat polymorphisms in the 5' UTR and 3' UTR of MYOC were genotyped using standard techniques. Association was assessed using FBAT.

Results: For the 5' UTR polymorphism, 3 common (13, 14 and 15-repeats) and 2 rare (12 and 16 repeats) alleles were found. FBAT showed weak evidence of decreased transmission of the 15-repeat allele ($Z = -2.26$, $p = 0.02$) when high myopia was considered as a dichotomous trait. However, after accounting for multiple testing (1 test for each of the five alleles), this result did not reach statistical significance. Models that considered myopia as a quantitative trait did not improve the strength of the association. For the 3' UTR, no association was detected. All alleles were in Hardy–Weinberg equilibrium.

Conclusion: According to accepted criteria, our findings do not support the hypothesis that MYOC is a high myopia susceptibility gene in Caucasian subjects. However, the pattern of MYOC allele transmissions was consistent with previous studies [1, 2], and therefore it may be that our sample size was insufficient to disclose a real, yet small, relative risk due to this gene. A larger sample size will be required to resolve conclusively whether alleles at the MYOC 5' UTR impart a small increased risk of high myopia in this population.

References:

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S004

Form deprivation myopia of the fish eye – optical and molecular change

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Purpose: This research examines whether the fish eye, which grows through life and is optically very different than the terrestrial eye, can be a useful model of form deprivation myopia and molecular control of refractive development.

Methods: Translucent goggles were sutured over the right eye of tilapia (Oreochromis niloticus), about 4 months old (26–63 g) for 4 weeks while the left eye served as a contralateral control. Refractive states were measured, ocular dimensions determined and lens focal lengths measured for both the goggled and untreated eyes. Also, 2-D Differential in Gel Electrophoresis (DIGE) and Mass Spectroscopy were used to identify differentially expressed proteins in retina/choroid tissue from goggled and untreated tilapia eyes. Annexin max 2, a protein showing significant expression changes, was PCR cloned from Tilapia retinal tissue. Targeted gene expression studies were carried out using semi-quantitative Real-time PCR on separated retinal and choroidal tissue.

Results: All the deprived fish eyes developed myopia ranging averaging 10.27 ± 1.14 D. Recovery took place 5 days after goggle removal. The vitreous and anterior chambers of the myopic eyes were significantly longer axially, while no difference in lens optical quality was found. Eighteen differentially expressed retinal proteins were found. Four were identified and one, annexin max 2, was down regulated 47% in tissue from myopic eyes. However, no differences were detected in gene expression between treatment groups at the 2-week time point and transcription levels were noted to be significantly higher in the choroid relative to the retina ($p < 0.0001$).

Conclusion: Although lower vertebrates are capable of lifelong growth, their eyes are susceptible to form deprivation myopia. Because of its differential expression in the retina, as well as its role in calcium transport and its relationship to retinoic acid, the protein annexin max 2 has been identified as an important candidate for further study.

S005

Inter-ocular influences in the chick myopia model

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Purpose: To examine the influences that one eye of the chick has on its fellow eye in various treatments that affect their

refractive states and to determine the nature of these interactions.

Methods: Chicks were raised in various illumination regimes including 12/12 light/dark (12L/12D), continuous light (CL), and continuous darkness (CD) with or without opaque patching of one eye. In separate experiments, light transmission between the eyes was measured using direct and microscopic digital photography and calibrated using neutral density filters. Corneal curvature was measured with infrared keratometry, ocular dimensions with 'A' scan ultrasound, and refractions with neutralising, infrared video retinoscopy.

Results: The patched right eyes of chicks raised under 12L/12D became myopic, as is commonly observed in patching experiments. However, the patched right eyes of chicks raised under constant light conditions became hyperopic, but not as hyperopic as their non-patched fellow eyes. Both patched and non-patched eyes became hyperopic in constant darkness. The measured attenuation of light passage through the retinas of both eyes is six log units. However, when the eyes are properly aligned an attenuation of as low as 2.5 log units may be observed, indicating that the light is transmitted via another pathway that we believe to be via the optic nerves. Covering the eyes in CD had no differential effects on the eyes, indicating that temperature effects of the patches were unimportant.

Conclusion: The illumination regime of a fellow eye has a profound influence on that of the patched eye, causing it to be either myopic under 12L/12D or hyperopic under CL with corresponding alterations of corneal curvatures, and anterior and vitreous chamber depths. A possible pathway for this influence is retro-illumination from the fellow eye.

S006

Variable responses of tree shrew eyes to plus lenses, myopic defocus and recovery from induced myopia

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Purpose: To examine the responses of tree shrew eyes exposed to three conditions of myopic refractive error: plus lens wear, myopic defocus with controlled viewing distance, and recovery from an induced myopia.

Methods: Groups of tree shrews wore binocular plus lenses (+3D, +5D) with no control of viewing distance. 'Lens competition' groups wore plus lenses (+3D, +4D, +5D) 45 min per day while all objects were at least 1 m away. The rest of the time they wore a –5 D lens. In seven groups of tree shrews, myopia was induced with a monocular –5 D lens, then the lens was removed and recovery observed. One of these groups wore a +2 D lens during recovery.

Results: Binocular plus lens wear slowed the normal developmental progression from hyperopia to emmetropia in 9 of 10 animals. One animal became significantly hyperopic. With controlled viewing distance, low power plus lens wear blocked compensation to the –5 D lens in 11 of 20 tree shrews. Twenty-three of 31 animals with induced myopia recovered until the treated eye matched the control eye. The other eight did not recovery fully. Four of five animals wearing the +2 lens recovered only until the eye matched the control eye without the lens. They remained myopic wearing the +2 lens.

Conclusion: Tree shrews seem more variable than chicks in their response to myopic defocus. Some eyes are able to distinguish between myopic defocus and hyperopic defocus. Others either do not detect the myopic defocus or do not use it to control axial elongation. Like some humans, some tree shrew eyes tolerate remaining myopic and do not recover fully from an induced myopia. Myopic refractive error is more effective in elongated eyes but does not guide eyes to become smaller than untreated control eyes.

S007

Flicker conditions with fast-on characteristics inhibit myopia development irrespective of the form of the off component

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Purpose: Rapid temporal changes of environmental illumination, produced in a number of ways (e.g. strobe, rotating chopper disc), have been shown to inhibit myopia development, and conditions that stimulate the ON pathway (e.g. fast-on, slow-off) appear particularly effective. We sought to determine which components of the temporally modulated waveform were critical for myopia inhibition.

Methods: Rhode Island Red-Rhode Island White cross chicks (n = 8–9 per group) were monocularly fitted with either diffusers (FDM) or -15 D lenses (LIM) on post-hatch day 8. Chicks were exposed to 12 h of flickering light produced by a computer driven bank of 9 light emitting diodes (5 watt, white, Luxeon), at a frequency of 5 Hz and peak illuminance of 1000 lux (at the cage-floor), which had one of 5 temporal profiles: (1) fast-on, slow-off, (2) slow-on, fast-off, (3) slow-on, slow-off, (4) fast-on, fast-off, (5) fast-on, on, slow-off. A control group was raised under normal lighting conditions (no flicker, 250 lux). After 4.5 days of treatment, refractive error and axial length were measured under 2% isoflurane anaesthesia.

Results: The waveform characteristics of the illumination significantly affected the amount of myopia produced (diff RE: $F5, 100 = 20.676$, $p < 0.001$; diff AL: $F5, 100 = 19.936$, $p < 0.001$). This was independent of the form of the myopia inducing treatment (diff RE: $F1, 100 = 0.766$, $p = 0.384$; diff AL: $F1, 100 = 0.486$, $p = 0.487$). Both forms of myopia and the associated axial elongation were inhibited best by wave-

forms with fast-on characteristics, irrespective of the nature of the off component (e.g. FDM: fast-on, slow-off, −1.94 ± 5.01 D, 0.16 ± 0.22 mm; fast-on, fast-off, −3.47 ± 4.91 D, 0.17 ± 0.24 mm; fast-on, on, slow-off, −1.64 ± 3.53 D, 0.20 ± 0.22 mm), and least by waveforms with a slow-on profile (e.g. FDM: slow-on, fast-off, −8.59 ± 5.24 D, 0.41 ± 0.21 mm; slow-on, slow-off, −8.81 ± 4.25 D, 0.44 ± 0.18 mm).

Conclusion: Consistent with previous studies, luminance conditions which preferentially stimulate the ON system inhibit myopia development. The form of the initial luminance rise of the waveform was critical for myopia inhibition and the form of the off component appeared relatively unimportant.

S008

An evidence-based analysis of treatments for choroidal neovascularisation in pathologic myopia

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Purpose: To evaluate the different treatment modalities available for choroidal neovascularisation (CNV) secondary to pathologic myopia.

Methods: A MEDLINE search was carried out on studies or reports pertaining to treatment of CNV in pathologic myopia. The primary objective was to evaluate the efficacy of different treatment options.

Results: The treatment options for myopic CNV include photodynamic therapy (PDT), laser photocoagulation, submacular surgery, macular translocation, and selective occlusion of CNV by indocyanine green (ICG)-mediated photothrombosis at the CNV ingrowth site. There were three randomised clinical trials favoring the use of PDT for the treatment of CNV in pathologic myopia. PDT for subfoveal CNV due to pathologic myopia was found to provide visual benefit that maintained through 2 years follow-up compared with a placebo therapy. Laser photocoagulation for non-subfoveal myopic CNV showed initial or short-term visual benefit for between two and 24 months, but eluded a longer beneficial effect. Submacular surgical removal of subfoveal CNV did not provide any significant visual improvement. Macular translocation for subfoveal CNV in pathologic myopia appear to offer some promise in selected cases. ICG-mediated photothrombosis was claimed to produce obliteration of the neovascular complex with some visual acuity improvement.

Conclusion: Currently, PDT is the only treatment that has been proven efficacious by large randomised controlled trials for subfoveal myopic CNV.

S009

Macular pathological changes in high myopia – a review of findings on optical coherence tomography

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Purpose: To review the current knowledge of myopic macular pathological changes on optical coherence tomography (OCT).

Methods: A systematic review of published literature on OCT features of macular degenerative changes in myopia was done.

Results: Cross-sectional clinic based studies ($n = 6$) have described the prevalence of macular pathological findings on OCT in 717 patients (983 eyes). The degree of myopia ranged from −6.00 to −36.00 diopters. Prevalence of myopic retinoschisis ranged from 3.6% to 31% in different study populations. Epiretinal traction (9% to 46%), macular holes (6% to 10%), foveal retinal detachment (9% to 28%) and choroidal neovascularisation (9%) were the other common findings noted. Posterior vitreous schisis was reported in 75% eyes with macular holes in one study.

Conclusion: OCT with its cross sectional imaging capability has further improved the understanding of the subtle myopic macular pathological changes that may be clinically less apparent. Larger population based prevalence studies are required to better understand the exact prevalence of these features in eyes with high myopia.

S010

Fundus changes and eye shape in high myopia

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Purpose: To discuss and document the adult age progression of posterior fundus changes and their possible correlation to eye shape in a representative sample of Danish adolescents with high myopia.

Methods: A regular ophthalmic follow-up over 40 years of 39 initially unselected Copenhagen 14-year-olds with uni- and bilateral myopia of at least −6D, as screened from a 1948 birth-year school cohort comprising 9,243 pupils. Thirty-four of the 39 had repeated fundus photos and ultrasound A- and B-scan data for longitudinal analysis.

Results: Myopia progression for the full period ranged 0–14 D, and the peak myopia value increased from −14 to −26 D. The mean progression from age 16–26 years was 2.0 D (SD 2.07), and from age 26 and on it was 0.98 D (SD 1.84). Myopia progression was highly correlated to axial elongation ($r = 0.65$). Twenty-one of the 34 had a round regular shape of their eyes, whereas an irregular shape was described in 13 subjects. A ratio was calculated between axial length and transversal diameter values. There was a range from 0.91 to

1.16, however with 39/67 'equal' eyes clustering within ratio values of 0.98–1.06. Nine eyes were in the range of 0.91–0.97 ('broad' eyes), and the remaining 19 were 'long' eyes (ratio 1.07–1.16). Posterior fundus changes (peripapillary atrophy and macular degeneration) were correlated to axial length whereas eye shape appeared less decisive.

Conclusion: There seems to be an association between degree of myopia at age 14 and consecutive posterior fundus changes and visual loss, but except myopia above 9 D it was not possible to identify prognostic high risk factors at that early age.

S011

Posterior segment complications of laser in situ keratomileusis

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Purpose: To describe the posterior segment complications following laser in situ keratomileusis (LASIK) for the treatment of myopia.

Methods: A systematic review of all English-language articles and abstracts published in peer-reviewed journals indexed in MEDLINE from 1965 to April 2006 was performed to assess the posterior segment complications of LASIK.

Results: More than 30 publications were identified which addressed posterior segment complications of LASIK for the treatment of myopia. Myriad complications including retinal phlebitis, aggravation of proliferative diabetic retinopathy, cilioretinal artery occlusion, full thickness macular hole, macular hemorrhage, uveal effusion, peripheral retinal break, retinal detachment and retinal nerve fibre loss have been reported following LASIK.

Conclusion: Serious posterior segment complications after LASIK are not infrequent. A dilated fundus examination is very important before LASIK and in every patient whose visual acuity after LASIK is not as good as expected to avoid delayed referral to a vitreoretinal specialist. However, we need more prospective studies to assess the true impact of vitreoretinal pathology following LASIK.

S012

Photodynamic therapy for subfoveal choroidal neovascularisation secondary to pathologic myopia

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Purpose: To determine the efficacy and safety of photodynamic therapy with verteporfin (PDT) in subfoveal choroidal neovascularisation (CNV) secondary to pathologic myopia (PM).

Methods: Consecutive patients with CNV secondary to PM presenting to a tertiary retinal practice were recruited and treated with PDT. Primary outcome was the avoidance of 8-letter loss (1.5 Snellen lines). Secondary outcomes were avoidance of 15 letter loss (3 Snellen lines), change in mean visual acuity and proportion of patients with visual improvement ($>$ 5 letters). Ocular and systemic adverse events were recorded. Minimum follow up period was 12 months.

Results: Forty-two eyes of 42 patients were treated. Mean follow up period was 18 months. 90% of patients avoided 8-letter loss of vision. 20% experienced significant visual improvement. No ocular adverse events were recorded. Two patients had mild transient backache. No photosensitivity reactions were reported.

Conclusion: PDT is a safe and effective treatment option for patients presenting with subfoveal CNV secondary to PM.

S013

Myopic choroidal neovascularisation – a review of the natural history and prognostic factors

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Purpose: To study the epidemiology, natural history, and prognostic factors of myopic choroidal neovascularisation (CNV).

Methods: A PubMed search was performed to review English-language publications on myopic CNV.

Results: In a review of the causes of CNV in a group of patients younger than 50 years of age, high myopia was the aetiological factor in 62% of cases. One study of 354 eyes with myopic CNV demonstrated that 96% of choroidal neovascular membranes remained stable or regressed with scarring. However, the visual prognosis of untreated myopic CNV is poor, with final visual acuities (VA) of 20/100 or less in several studies. In a review of 100 untreated eyes, 100% of lesions involved the foveal centre after 5 years, with a mean visual acuity of 20/160. The visual acuity in the untreated group was significantly lower than a similar group that was treated with laser photocoagulation. A 10-year follow-up of 27 eyes of Asian patients demonstrated that VA dropped to 20/200 or worse in 88.9% and 96.3% of patients after 5 and 10 years respectively. The drop in visual acuity may be related to the development of chorioretinal atrophy. Prognostic factors for visual outcome of myopic CNV include the age at onset of CNV, location and size of CNV and the initial best-corrected visual acuity.

Conclusions: Pathologic myopia is the cause of CNV in a large proportion of patients younger than 50 years of age. A review of its natural history reveals that the long-term visual prognosis of untreated CNV is poor, with visual acuities of 20/100 or less after 5 to 10 years in a large proportion of patients.

S014

New surgical approach to myopia related retinal conditions

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Purpose: Patients with high myopia have an increased risk of developing retinal detachment. Pathological myopia is often associated with staphyloma and in some cases, macular hole retinal detachment. The study below utilised the new 23-gauge sutureless vitrectomy system in treatment of the above conditions, with excellent surgical outcome, minimal postoperative discomfort and faster visual rehabilitation.

Methods: A total of 22 cases with rhegmatogenous retinal detachment and 7 cases of macular hole retinal detachment secondary to pathological myopia with staphyloma underwent 23 gauge primary vitrectomy without scleral buckle. All 7 cases of macular hole retinal detachment had heavy silicone oil (Oxane HD) as an endotamponade whereas the 22 cases of rhegmatogenous retinal detachment underwent primary vitrectomy with C3F8 gas tamponade. Treatment outcome measures include visual acuity pre- and post- operation, anatomical retina reattachment and intraoperative and postoperative complications.

Results: All cases underwent successful surgeries with no major complications intraoperatively. Mean follow-up period was 9 months. Postoperatively, there was one case of raised intraocular pressure in a patient with macular hole retinal detachment with oil tamponade. There was no case of wound leak or hypotony in the series. All cases with rhegmatogenous retinal detachment had successful anatomical reattachment postoperatively although there was one case of redetachment secondary to proliferative vitreoretinal retinopathy at 3rd month post-operation. In all seven cases with macular hole retinal detachment, all had successful reattachment of the posterior pole with closure of the macular hole following removal of the oil tamponade at 3rd month post-operation. All cases had visual improvement from 2 lines to more than 15 lines, depending on the chronicity of the condition and whether the macula was detached in the initial presentation. Postoperative recovery in all patients was uneventful with minimal discomfort due to the new sutureless technique.

Conclusion: The new 23-gauge vitrectomy is highly safe and effective in the treatment of rhegmatogenous retinal detachment with gas tamponade and in macular hole retinal detachment with oil tamponade in pathological myopia. No major complications were reported in this series with good surgical outcome and improved postoperative recovery and patient comfort.

S038

Molecular genetics of high myopia

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Purpose: Six chromosomal loci have been mapped as myopia loci and two candidate genes have been suggested to be associated with myopia. We have conducted a series of studies to map the myopia-associated locus and identify the myopia gene(s).

Methods: Candidate genes were screened for mutations by PCR and direct sequencing in a cohort of high myopia patients and age and sex matched control subjects who were all Hong Kong Chinese. Whole genome scan was performed on pedigrees utilising microsatellite markers followed by fine mapping and candidate gene screening within the promising linkage regions.

Results: We have previously narrowed a myopia locus at 18p to the region flanking D18S476 and identified TGIF, which is located within the region, as a possible candidate gene. The 488T allele of a polymorphism P163L (488C > T) was found significantly less frequent in patients and therefore could confer protective effect against high myopia. For PAX6, a recently reported putative myopia gene, one sequence change in the promoter region, −971G > C, was found to be significantly higher in high myopia patients. PAX6 may be associated with high myopia. Further, our whole genome scanning on high myopia pedigrees suggested linkage in critical regions in 12q21.33 and 5p15. A candidate gene, lumican, within the linkage region on chromosome 12 was screened for sequence alternations in the myopia patients but no significant results were obtained.

Conclusion: A novel genetic locus on 5p15 has been identified for high myopia and another mapped locus on chromosome 12 overlapped with the reported myopia locus MYP3. Our results provide new information to aid in the identification of a novel gene for high myopia.

Free Papers

F001

A study of the effect of continuous low myopic defocus on myopia onset and progression in children

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Purpose: To study binocular and monocular myopic defocus effect on myopia development.

Methods: A total of 28 children aged 5–8 (group 1) with pseudomyopia (noncycloplegic & cycloplegic refraction ranges: −0.5 ± 0.06 D and +1.12 ± 0.1 D resp.) were prescribed, for continuous wear, plus lenses of +0.5 to +1.5D (depending on the refraction) that induced myopia of 1.0D. Group 2: 15 children aged 7–11 with low myopia (mean R. −1.25 ± 0.15 D) were prescribed alternating 'monovision' correction that induced anisomyopia of ≈1.0 D. Each eye was made myopic on alternate days, the other being corrected

for distance. All had binocular vision and dominant right eyes with and without correction.

Results: In group 1, a hyperopic shift occurred in 1–3 months and over the 3–5 years' follow-up period, refractions remained stable (+0.64 ± 0.04, +1.24 ± 0.09D for noncycloplegic & cycloplegic refractions resp.), anterior chamber depth (ACD) increased (3.02 ± 0.32 to 3.31 ± 0.34 mm) while crystalline lens thickness (CLT) decreased (3.95 ± 0.29 to 3.63 ± 0.41 mm). Axial length (AL) also changed minimally (22.34 ± 0.5 to 22.44 ± 0.58 mm). Most subjects showed orthophoria (73.5 cf. 26.5% exophoria) for near uncorrected and exophoria with correction (26.5 and 73.5% resp.). AC/A ratios averaged −1.52 PD/D. For group 2, 67% children showed stable refractions and ocular dimensions over 24 months (initial and final values 23.95 ± 0.64 & 23.90 ± 0.41 mm, AL; 3.68 ± 0.40 & 3.58 ± 0.47 mm, ACD; 3.47 ± 0.3 & 3.41 ± 0.24 mm CLT). There were associated decreases in exophoria and AC/A and NPC receded. The remaining 33% showed eye elongation and myopia progression (initial & final values: 23.60 ± 0.22, 24.27 ± 0.66 mm, AL; 3.11 ± 0.44, 3.42 ± 0.29 mm, ACD; 3.50 ± 0.22, 3.5 ± 0.23 mm, CLT), increases in exophoria and AC/A ratio, and NPC decrease.

Conclusion: Binocular hyperopic overcorrection (myopic defocus) of children with pseudomyopia appears to prevent myopia development. Alternating monovision, which provides better distance vision, also prevents myopia progression in low myopia although not as effectively as binocular overcorrection controlling myopia. We are grateful to C.F.Wildsoet of UC Berkeley for assistance in preparing this abstract.

F002

The effectiveness of progressive addition lens on Chinese juvenile-onset acquired myopia: the first year report

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Purpose: To report the first year's result of progressive addition lens with +1.50 D addition (PALs) on the myopic progression in Chinese juvenile-onset acquired myopes and their safety compared with single vision lens (SVLs).

Methods: We enrolled 179 Chinese juvenile-onset acquired myopes (ages 7–13, spherical equivalent refractive error, SER, ranges from –0.50 to –3.00 D) in Guangzhou city for an at least 2-year long cohort study, whom were randomly assigned to the PALs group and SVLs group. The primary outcome included myopic progression, determined by auto refraction after cycloplegia, and heterophoria status with spectacles at far (6 m) and near (0.33 m), measured by the Cover Test. And ocular biometry was also measured by A-scan ultrasonography. Only data of patients who reported good adherence to seeing through right parts of lens was used. Results were adjusted for important covariates, by using multiple linear regressions and were analysed by general linear model for repeated measures.

Results: Of the 179 children, 164 (92%) completed the first year visit, and 145 (88 %, 72 in SVLs and 73 in PALs) had good self-reported adherence. Their baseline characteristic included mean age 10.96 ± 1.56 years, SER −1.78 ± 0.71 D, and accommodation response 2.08 ± 0.31 D, phoria at near −1.28 ± 5.36. There was no statistically significant difference in all these baseline characteristic between two groups. After the first year, the myopic progression in SVLs and PALs groups were −0.76 ± 0.40 D and −0.63 ± 0.36D ($p = 0.011$), respectively. Mean increase in the axial length were 0.48 ± 0.34 mm and 0.35 ± 0.39 mm ($p = 0.005$), respectively. However, there was no difference in the heterophoria either at far or near ($p = 0.425$ and $p = 0.305$, respectively).

Conclusion: According to the first year's result, we could find, compared with SVLs, there was a statistically significant less myopic increase in PALs group and no difference in affecting heterophoria status. However, the long-term effect of PALs needs further observation.

F003

Results of a one-year prospective clinical trial (CONTROL) of the use of bifocal soft contact lenses to control myopia progression

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Purpose: CONTROL is a one-year prospective, randomised and double-masked clinical trial comparing the myopia progression of children with near eso fixation disparities when wearing bifocal soft contact lenses (BSCL) vs single vision soft contact lenses (SVSCL).

Methods: Multi-zone simultaneous vision BSCL and SVSCL were randomly assigned to children aged 8–18 years; groups were matched for age, sex, ethnicity, refractive error and degree of associated esophoria (BSCL, $n = 38$, SVSCL, $n = 40$). Masking was aided by the choice of lenses; both were 58% water, two-week disposable lenses, identical in appearance and supplied in masked packaging. Distance corrections generally matched subjective spherical equivalent refractions (SER) and bifocal additions were selected to maximally reduce near associated esophorias, while still maintaining clear distance vision. Baseline refractive error, binocular vision and biometric data were collected, with most measurements repeated after 6 and 12 months of lens wear. Data include cycloplegic subjective as well as objective refractions (with Nidek ARK 700A refractometer) and axial lengths (with Zeiss IOLMaster).

Results: Baseline cycloplegic subjective SERs at baseline for the BSCL and SVSCL groups, averaged across right and left eyes, were −2.76 ± 1.37 and −3.01 ± 1.44 D respectively (mean ± SD), changing across the 12-months study period by −0.10 ± 0.36 and −0.75 ± 0.50 D. Equivalent changes in

cycloplegic objective SERs were similar, i.e. −0.22 ± 0.34 vs −0.78 ± 0.45 D for BSCL and SVSCL groups. Axial lengths increased by 0.05 ± 0.14 and 0.24 ± 0.17 mm for the BSCL and SVSCL groups respectively. All intergroup differences in the changes across the study period are highly significant (*t*-test).
Conclusion: Bifocal soft contact lenses significantly reduce myopia progression relative to the changes seen with single vision soft contact lens wear. Whether their inhibitory effect on myopia progression persists beyond the first year of wear and/or is restricted to those with associated esophoria at near remains to be established.

F004

Quantitative analysis of myopic chorioretinal degeneration in Chinese eyes using a novel computer software programme – a preliminary report

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Purpose: To evaluate the feasibility of quantifying the degree of myopic chorioretinal degeneration (MCD) using a novel computer software programme.
Methods: In a pilot study, 171 colour fundus photographs were grouped into three categories (none, mild and severe) based on the degree of MCD as determined by a vitreoretinal surgeon. Using a novel computer software programme (MCD grading programme) designed to quantify the severity of MCD based on the number of RGB pixels in a section of the retina excluding the retinal blood vessels; an index called the MCD index (MCDI) was generated for each fundus photograph. Subsequently, in a clinical study, the MCDI was generated using the fundus photographs of 145 eyes of 73 Chinese subjects with varying degrees of refractive error (low, moderate and high myopia). The subjects also underwent a complete ophthalmic examination including refraction and axial length measurement.
Results: In the pilot study, the MCDI was statistically different among the 3 groups with no, mild or severe MCD ($p < 0.001$). In the clinical study, the MCDI was not statistically different among the 3 groups ($p = 0.11$), but for all eyes combined, the MCDI correlated with the axial length ($p = 0.001$) and refractive error ($p = 0.002$).
Conclusion: Our novel software programme is able to quantify the severity of MCD using the MCDI. Clinically, the MCDI correlated with the axial length and refractive error.

F005

In vivo measurement of inter-photoreceptor distance in myopia by adaptive optics fundus camera

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Purpose: Adaptive optics (AO) technology enables to visualise the photoreceptor cells (PR) in vivo by canceling ocular wave front aberration. The density of PR cells is reportedly lower in myopia than in emmetropia by histological study (Grossniklaus, Retina 1992). We examined the distance of PR cells in normal and in myopia using AO fundus camera.
Methods: Nineteen eyes of 19 subjects without ocular pathology (30.9 ± 10.4 years old; Mean ± SD) were investigated. The refractive error ranged from + 0.5 to −11.1 diopters (D) (−3.7 ± 3.3 D; Mean ± SD) and axial length ranged from 23.4 to 28.0 mm. (−25.4 ± 1.61 mm; Mean ± SD). AO fundus camera (Topcon corp.) equipped a 635 nm luminescence diode illuminator, and 768 × 768 pixel refractive liquid crystal light modulator (Hamamatsu Photonics), in which wavefront aberration was reduced up to 8th order. The liquid crystal device corrected wavefront aberration on time at 3Hz response rate. Fundus image was taken when RMS error was reduced below 0.10 μm. The inter-photoreceptor distance (IPD) was calculated manually and averaged in 3 different areas in each image at the retinal loci 2 degrees temporal from the fixation point. The magnification of the image was calibrated by the axial length.
Results: The average IPD in moderate to high myopia group (–4.71 ± 0.44 μm, −6.5 ± 2.3 D, $n = 9$), was significantly larger than that in normal and low myopia group (–3.90 ± 0.47 μm, −1.1 ± 0.9 D, $n = 10$). The IPD correlated with the axial length significantly (Pearson, $r = 0.77$, $p = 0.0001$).
Conclusion: The AO fundus camera was able to visualise photoreceptors in living eye with low to high myopia. The IPD in moderate to high myopia group was larger than that in emmetropia and low myopia group, which was consistent with the reported histological study.

F006

Retinal nerve fiber layer thickness in myopic amblyopic and hyperopic amblyopic subjects

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Purpose: To compare the retinal nerve fiber average thickness in Myopic Amblyopic and Hyperopic Amblyopic subjects (RNFLT).
Methods: Group I included 55 eyes of 55 subjects with hyperopic anisometropic amblyopia (defined) Group II included 28 eyes of 28 myopic anisometropic amblyopia of with decrease visual acuity difference of 2 line or more and difference of < 2.0 DSph. or equivalent spherical equivalent error) with or without ocular deviations. All subjects underwent complete ophthalmic examination including refraction,

measurement of ocular deviation with prism bar, axial length measurement. RNFLT was measured using optical coherence tomogram (Stratus OCT 3, Carl Zeiss Meditec, Dublin, CA, USA) after pupillary dilatation. Average RNFL thickness and RNFL thickness in four quadrants were compared between (hyperopic & myopic) amblyopic eyes using paired '*t*' test.

Results: Mean age in myopic anisometropic amblyopia was 16.1 year (SD: 7.2), in hypermetropic amblyopia 16.8 year (SD. 8.55). The average thickness in the hyperopic anisometropic myopic anisometropic amblyopia group was 99.10 ($p = 0.76$). The average RNFL thickness and in 4 amblyopic group was 98.18 quadrants were similar between two groups except temporal quadrant $p < 0.05$ (p values for all parameters were as follows Superior $p = 0.95$, Inferior $p = 0.8$, Temporal $p < 0.05$, Nasal $p = 0.94$).

Conclusion: RNFL average thickness were similar in two groups and appears to be unaffected by anisometropic amblyopia.

F007

A technique for buckling the posterior pole in progressive axial myopia: issues of safety and efficacy

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Purpose: Axial length over-growth and stretching have been implicated in the causation of vision loss from myopic macular degeneration. This study evaluates the safety and outcomes of a surgical procedure designed to place tensioned scleral buckles over the posterior pole of the human eye, for the control of progressive axial myopia.

Methods: Clinical data is presented on 100 eyes, which were treated by posterior pole buckling. Long strips of sclera were removed from processed donor eyes and placed over the posterior poles of eyes having progressive, high, axial myopia. All donor tissue was tested for potential pathogens, to the standards used for tissue destined for corneal transplantation. The recipient eyes were closely monitored during the post-operative period. Medications were used to prevent local infection, to control the intra-ocular pressure and to suppress excessive inflammation, congestion and swelling. The efficacy of the technique was assessed by regular examinations and by ultrasound measurements of the axial length.

Results: No sight-threatening complication occurred in any eye. None of the major complications, reported for other methods of scleral reinforcement, was observed in this series. Axial length stabilisation was achieved in eyes buckled in the second through the sixth decades of life, with follow-up of eighteen months to ten years. The, later, resumption of some slower rate of axial extension was noted in one third of the younger eyes. After support, a small increase in visual acuity was noted in a small number of eyes.

Conclusion: The technique described was found to be safe, and to result in positive axial myopia control in the majority of eyes. Some limited visual acuity improvement was noted. Any safe technique that limits axial myopia progression deserves attention, as it may reduce future myopic macular degeneration and its associated loss of visual acuity.

F009

Pilot study of prediction the outcome of phacoemulsification in cataract patients with high myopia by OCT and electrophysiological examination

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Purpose: To study the postoperative visual acuity results of phacoemulsification of the cataract with high myopia and the effect of estimating the outcome of phacoemulsification of cataract with high myopia by optical coherence tomography (OCT) and electrophysiological examinations.

Methods: This retrospective study comprised 56 eyes having phacoemulsification and implantation of intraocular lens. The preoperative and postoperative visual acuity, corneal endothelium cell counting, axial length, visual evoked potential (VEP), multifocal electroretinogram (mERG), OCT, and complications were analysed.

Results: A total of 98.2% postoperative VA was improved. No significant difference was found between preoperative and postoperative endothelium cell number. No complication occurred during following up. The VEP results showed significant difference between cataracts eyes with postoperative visual acuity better than 0.3 or not. There is significant difference of visual acuity among the eyes with different amplitudes of P wave in the first ring collected in mERG. With OCT examination, 22 eyes in this study were found concurred severe retinopathy, including macular atrophy in 8 eyes, macular hole in 6 eyes, macular hemorrhage in 3 eyes, retinoschisis in 2 eyes and foveal retina detachment without macular hole in 3 eyes. Among these eyes, the best postoperative visual acuity is 0.5 and the worst postoperative visual acuity is 0.02.

Conclusion: Phacoemulsification and implantation of intraocular lens is a viable and safe technique to correct the high myopia associated with cataract. OCT and electrophysiological examinations can be useful tools in estimating the postoperative visual acuity.

F010

Effects of corneal refractive surgery on visual performance for diving

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Purpose: To evaluate the effects of corneal refractive surgery (CRS) on Visual Acuity (VA), Contrast Sensitivity (CS) and

Intraocular Pressure (IOP) under 3 different chamber dive conditions.
Methods: VA, CS and IOP were measure before and after the 3 different chamber dives, and before and after surgery, which was 6 months apart. A total of 112 eyes (no outliers) were analysed with 61 eyes that did PRK and 51 eyes underwent LASIK. EDTRS charts were used to determine the VA, while Pelli-Robson charts were used to measure CS and IOP was measured using Goldmann contact tonometer.
Results: In Paired sample *t*-test, there was a drop in IOP after Dive1, 0.590 mmHg for pre and 0.661 mmHg for post CRS. In addition, VA improved by 0.01LogMAR post CRS after Dive2. When a multivariate test was done, it was shown that diving affects IOP, especially Dive1.
Conclusion: The study had shown that CRS, regardless of PRK or LASIK, do not have any adverse effects on the visual performance for diving. Therefore, CRS is not a contra indication for diving.

F011

A long-term prospective follow-up study of myopic photorefractive keratectomy

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Purpose: To evaluate long-term refractive stability of excimer laser myopic photorefractive keratectomy (PRK).
Methods: A long-term (11 years) prospective follow-up study of visual and refractive outcome of patients who had PRK surgery performed in 1994 and 1995. All levels of myopia were included in this study. 46 patients (85 eyes) of the original cohort of 92 patients who participated in the '3 Years' follow-up of excimer laser PRK for myopia (published in *Journal of Shandong University*, Vol 38, no 3) underwent detailed clinical assessment at 11 years. Myopic PRK was performed using the Summit Technology Apex excimer laser with a 6-mm ablation zone. The main outcome measures were safety, predictability, efficacy and stability. Aberrations, topography, pachymetry, and postoperative complications were also recorded. Furthermore, all patients received a questionnaire including 11 items to survey individual satisfaction.
Results: Preoperatively, the mean spherical equivalent was −5.15 diopters (D). At 11 years postoperatively, 56.5% of eyes were within ± 0.5 D of attempted correction with 81.2% within ± 1.0 D. 87.0% of eyes had a vision of 6/12 or better and 51.7% of 6/6 or better. Best spectacle corrected visual acuity (BSCVA) was unchanged or improved in 90.6%. 8 eyes lost their BSCVA, mostly with severe myopia, including 5 eyes lost one line, 1 eye lost two lines and 2 eyes lost more than two lines. Overall, there was regression of 0.72D in refraction towards myopia in which severe (over −6.00 D) subset showed a significant change between 3 and 11 years. Complications were rare and there was a high level of patient satisfaction with the surgery.
Conclusion: Myopic PRK surgery offers predictable and stable results in terms of refractive and visual outcome with mild regression in refraction, which mainly lies in severe myopes.

F012

Relationship between axial length and retinal thickness in high myopes

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Purpose: Recent research found axial length positively correlated with parafoveal retinal thickness but negatively correlated with foveola retinal thickness. Our aims were to determine whether there is significant difference in central fundus (within 6 mm) between emmetropes and high myopes (more than −6 D).
Methods: Optical Coherence Tomography was used to measure the retinal thickness of the macular region (macular, central 1-mm zone, central 3-mm zone and central 6-mm zone) for ophthalmically normal emmetropes (SER between +1 D to −1 D) and high myopes (more than −6 D, with astigmatism less than −2 D). The axial length was measured by IOL master.
Results: The retinal thickness of both emmetropes ($n = 33$, age = 21 ± 1.4 year, SER ranged from −0.98 D to +0.88 D) and high myopes ($n = 33$, age = 22 ± 2.7 year, SER ranged from −6.10 D to −11.22 D) were measured. The axial length was significantly correlated with three regions (macular: $r = -0.56$, $p = 0.0007$; central 3-mm zone: $r = -0.36$, $p = 0.0399$; central 6-mm zone: $r = -0.58$, $p = 0.0004$) except the central 1-mm zone ($r = -0.0532$, $p = 0.7686$) in the high myopes. The retinal thickness for high myopes were significantly thinner than emmetropes by 13.24 μm (unpaired *t*-test, $t = 4.493$, $p < 0.0001$), 8.350 μm (unpaired *t*-test, $t = 3.204$, $p = 0.0021$) and 14.87 μm (unpaired *t*-test, $t = 14.866$, $p < 0.0001$) in the macular, central 3-mm zone and central 6-mm region respectively. No significant difference in retinal thickness was found between emmetropes and myopes was found in the central 1 mm zone (unpaired *t*-test, $t = 1.1315$, $p = 0.1930$).
Conclusion: The retinal thickness at macular and paramacular region (up to 6 mm diameter) decreases when axial length increases. High myopes (more than −6 D) had significantly thinner macular than the emmetropes.

F013

Eyes of lower vertebrates are susceptible to visual environment

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Purpose: Recently it was found that form deprivation myopia can be induced in fish, providing a new animal model in which the eye develops through life (Shen et al, 2005). This study further investigates the susceptibility of the fish eye to the manipulation of the visual environment.

Methods: Goggles with lenses having refractive powers of either +15 D or −12 D (in water) were sutured on the right eyes of Nile Tilapia (Oreochromis niloticus) for two weeks to induce hyperopia or myopia. The untreated contra lateral eye served as a control. The fish were refracted by retinoscopy while retinal thickness was measured by OCT (Optical Coherence Tomography). Changes in ocular dimensions were measured by freeze sectioning of excised eyes. In other experiments, translucent goggles were applied to the treated eyes for two weeks to induce form deprivation myopia in fish of three different weights to provide an evaluation of the effect of age. A ring of plastic without a central goggle was applied to the eyes of an additional group of fish as a control for suturing.
Results: The + 15 D lens-treated fish became hyperopic (+7.73 ± 1.59 D) while the −12 D lenses induced myopia (−8.43 ± 0.75 D) within two weeks. The hyperopic eyes were shorter and the myopic eyes longer, while the control group did not show any significant change in refractive state or ocular dimensions. After being treated with minus lenses, retinal thickness of the eye became thinner, and then thickened within 8 h after removing the goggles. Although not as evident, induced hyperopia produced the opposite effect. Form deprivation myopia was produced for three different age/weight groups (15 g group −11.92 ± 2.89 D; 60 g group −6.30 ± 2.52 D; 100 g group −2.26 ± 1.04 D). All treated eyes recovered to pre treatment levels within one week of goggle removal.
Conclusion: Lower vertebrates such as fish are susceptible to both form deprivation and lens-induced change, as is the case for higher vertebrates. The level of susceptibility is age dependent.

F014

Plus lens wear in young, hyperopic tree shrews halts progression toward emmetropia

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Purpose: To learn whether plus lenses applied early in the emmetropisation process, while tree shrews are still hyperopic, will cause eyes to stop when they reach emmetropia with the lenses in place.
Methods: Four tree shrews, under anesthesia, were fitted with a goggle frame attached to a pedestal at 10 or 11 days after eye opening (e.g., days of visual experience, VE). The next morning, the goggle frame containing binocular plus lenses (+3 D, 2 animals, +4 D, 2 animals) was clipped to the pedestal. The animals wore the plus lenses continuously except for two brief lens-cleaning periods each day. Daily non-cycloplegic refractive measures were made with a Nidek auto refractor, both with and without the plus lenses.
Results: The plus lenses partially corrected the 3.5–7 D of hyperopia present at the start of lens wear. In contrast to the normal progression from ~20 D of hyperopia at eye opening to emmetropia by 3–4 weeks of VE, all four animals arrested their progression when they were near emmetropia while wearing the plus lenses. Measured without the lenses, all were hyperopic. When lens-wear was discontinued in one animal, the hyperopia quickly declined to emmetropia as the emmetropisation process resumed.
Conclusion: Previous studies found that tree shrews at this age were insensitive to form deprivation and concluded the visual environment did not affect emmetropisation before the animals were two weeks of VE or older. This study shows that younger animals are susceptible to the environment if they wear plus lenses that correct their hyperopia – the eyes are able to slow their elongation rate when they are emmetropic wearing the plus lenses. It also contrasts with previous studies that found little effect of plus lenses in older tree shrews that had nearly reached emmetropia. It seems that it is difficult for tree shrew eyes to move from emmetropia to hyperopia, but they are able to stop the progression from high hyperopia when they wear plus lenses that provide an emmetropic visual experience.

F015

A global retinal proteins expressions involving compensated myopia by proteomics approach

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Purpose: To apply the proteomics application in studying the protein profiles changes in the developing chick retina and to investigate the differential retinal protein expressions in response to the compensated myopia.
Methods: The retinal tissues were harvested from normal developing chicks and also from emmetropising retinal tissues under −10 D lens treatments. Protein profiles were generated by either two-dimensional gel electrophoresis (2-DE) followed by silver stain or by 2-D Fluorescence Differential Gel Electrophoresis (DIGE). The retinal protein maps were analysed using the Image Master 5 gel matching software or using the Decyder software. Retinal protein spots were excised and in-gel digested with trypsin. Mass spectra were acquired from a Bruker Autoflex MALDI-TOF Mass Spectrometer and the resulting peptide maps were searched against the NCBInr database via the Mascot search engine for protein identification.
Results: Software analysis showed strong similarity in the protein profiles among the three groups of developing chick retinae and also between the defocus and control eyes. Five differentially expressed proteins involved in the chick retinal growth were successfully identified by MALDI-TOF peptide mass fingerprinting. Comparing the protein profiles between the defocus and control eyes, two candidate protein spots were suggested to be involved in the compensated myopia growth by using the conventional 2-DE while more candidate proteins could be found using the more sensitive DIGE approach. Systematic differences between these two proteomic approaches in terms of efficiency and accuracy were significant.
Conclusion: Proteomics is a powerful research approach and can contribute to myopia research in profiling the protein changes in myopia. A number of candidate proteins which might be involved in the compensated myopic growth of the chick retina were identified for the first time in our current study.

F016

Local mechanisms for interocular humoral communication (yoking) in chick

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Purpose: In studies of ocular growth regulation, some monocular manipulations have been reported to affect the fellow untreated as well as treated eye of chicks. We investigated the permeability of the thin interorbital cartilage plate that separates their two eyes as a possible route for the exchange of critical humoral factors. We also investigated the chick's lacrimal drainage system as an alternative interocular communication link.

Methods: The permeability of the interorbital cartilage plate was assessed using two different sized fluorescein isothiocyanate dextran molecules, 4.4 KDa (FD4) and 71.2 KDa (FD70) ($n = 7$ for both). Plates from 30 day-old White Leghorn chicks (*Gallus gallus domesticus*) were mounted in a Ussig chamber with the two surfaces of the plates exposed to either chick ringer (CR) solution alone (bottom compartment) or combined with FD (approximately 1.375% solution, top compartment). After incubation for 30 min in 5% CO2 at 35°C, fluid from both compartments was analysed spectrophotometrically (at 520 nm). A 50 μL drop fluorescein-labeled CR was instilled monocularly in other awake chicks, positioned on their side with their fellow untreated eye facing down. After 1 min, the tear layers of both eyes were inspected for fluorescence.

Results: There was significant diffusion of FD4 ($p < 0.03$, 2-tailed *t*-test) but not FD70 through the cartilage plates: fluorescein concentrations (mean ± S.E.M.) in the lower compartments reached 2.53 ± 0.89 and 0.22 ± 0.1 μg μL^{-1} for FD4 and FD70 respectively and were significantly different from each other ($p < 0.03$, unpaired *t*-test). Fluorescein was observed in the tear layer of both eyes after its monocular topical application.

Conclusion: Observations of fluorescein exchange across the interorbital cartilage plate in vitro, and between the tear layers of the two eyes in vivo, offer two local mechanisms for interocular communication that may contribute to the contralateral (yoking) responses noted with monocular visual and drug manipulations in the chick.

F017

Competing defocuses introduced by concentric bifocal lens result in summated emmetropisation response in chicks

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Purpose: We sought to investigate the effect of simultaneous competing defocuses on emmetropisation response of chick eyes.

Methods: Concentric bifocal lenses were applied to one eye of 8-day-old chicks. The powers of the lens was manufactured to produce competing defocuses of different combinations: (a) +20/−10 D, (b) +10/−10 D, (c) +5/−10 D, (d) 0/−10 D. And for a subset of (b), the relative intensity of the defocuses was varied from the original ratio of (a) 50:50 to (e) 33:67 and (f) 25:75 by manipulating the pitch width and number of annulus on the lenses. Control groups were established using single power lenses of power +20, +10, +5, 0, −10 D. Refractive error and axial dimensions were monitored by retinoscopy and A-scan ultrasound for 6 days at 2 days intervals.

Results: The competing defocus induced intermediate emmetropisation responses in all treatment groups except group (f). Refractive errors (treatment eye minus control eye) at day 6 after lens wear were: (a) +13.47 D, (b) +4.72 D, (c) –0.58 D, (d) –3.88 D, (e) −6.70 D, (f) −9.25 D. They are significantly different from their corresponding single defocus control group at the 0.05 level ($n = 10$–15). The refractive errors stabilised at positions where no apparent sharp image is focused on the retina. A positive quantitative relationship between the resultant response and the relative strength of the competing stimuli was evident in the experiment subset comprising group (b), (e) and (f).

Conclusion: These findings suggest that the eye can discern the sign of imposed defocuses, and an integrative process or summation of multiple defocuses may be employed in the decoding of visual stimuli for emmetropisation. We postulate that multiple defocuses simultaneously presented in the visual environment may play a pivotal role in emmetropisation and refractive error development.

F018

Derangement of pigment epithelium-derived factor (PEDF) activity in progressive and complicated myopia

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Purpose: According to previous observations (E.Iomdina et al., 2004), limited proteolysis of PEDF occurring in Tenon's capsule of hyperopic patients is almost suppressed in progressive myopia: in Western blot analysis the band corresponding to the full-length PEDF molecule (˜50 kDa) was more intensive in myopia than in hyperopia and another band (˜45 kDa) was much weaker in myopia than in most cases of hyperopia to compare PEDF of sclera and Tenon capsule and study its activity in patients with progressive and complicated myopia.

Methods: Tenon's capsule and sclera samples were obtained during scleroplasty, surgeries for squint and eye trauma from 43 patients aged 6–23: 16 patients with moderate progressive myopia (–3.5 to –5.75 D), including nine patients

with various forms of peripheral vitreochorioretinal dystrophies (PVCRD), 16 patients with high myopia (–6.0 to –20.0 D), including nine patients with PVCRD, and eight patients with low or moderate hyperopia. PEDF content in sclera and Tenon capsule homogenates was determined by Western blot analysis using polyclonal antibodies against the PEDF molecule fragment 345Lys-366Glu. Additionally, electronic microscopy was performed on 8 Tenon and scleral samples.

Results: PEDF of sclera and Tenon's capsule are practically identical. Dramatic differences in the content of PEDF isoforms between complicated and non-complicated myopia were noted. The intensity of the upper band corresponding to the full-length PEDF molecule was 10 or more times higher than that of the lower band in 75% cases of non-complicated and in 37% cases of complicated myopia whereas in hyperopia the intensities of these bands are almost equal. The most significant difference was noted in non-complicated moderate myopia where in 100% cases the intensity of upper band was at least 10 times higher.

Conclusion: In progressive myopia, especially prior to PVCRD development, PEDF accumulates and does not dissolve, which testifies to pathologic remodeling of sclera and internal shells during myopia progression.

F020

Effects of PD102807 on the proliferation and cell cycle of human scleral fibroblast cells

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Purpose: To primarily culture and identify human scleral fibroblasts. To observe the effect of a new selective M4 receptor antagonist PD102807 (Pfizer Inc, USA) on proliferation of human scleral fibroblasts (HSF) and to study the possible role of PD102807 in myopic scleral remodeling.

Methods: Primarily culture and identify human scleral fibroblasts. Observe the morphologic changes of HSF under the stimulation of PD102807. Investigate the effect of PD102807 at different concentration (5, 10, 20, 30, 40 μM) on proliferation of HSF cultured in vitro at different time point (24, 48, 72 h) using MTT method. Detect the effect of PD102807 on cell cycle of human scleral fibroblasts using flow cytometry.

Results: The morphology of HSFs became long and thin, the cell population reduced evidently in 72 h after the application of PD102807 which the concentration higher than 5 μM. PD102807 significantly inhibit proliferation of HSFs dose dependently ($p < 0.05$). The 50% inhibiting concentration (IC50) is 20 μM. PD102807 at concentration higher than 50 μM induced obvious apoptosis of HSFs. PD102807 at 20 μM significantly inhibit proliferation of HSFs in 48 h ($p < 0.05$), and is time dependently. PD102807 significantly increased the percentage of G1/0 phase cells, decreased S phase cells, reducing the proliferation index (PrI) of HSFs ($p < 0.05$) dose dependently as measured by flow cytometry. The PrI (S + G2M) was 13.00% ± 2.25%, 10.30% ± 1.10%, 8.20% ± 1.80%, 7.30% ± 1.35%, respectively, at different concentration (0, 10, 20, 30 μM).

Conclusion: PD102807 significantly inhibited proliferation of HSFs both dose and time dependently. It may inhibit proliferation through increasing the percentage of G1/0 phase cells, decreased S phase cells.

F021

Family-based association analysis of hepatocyte growth factor (HGF) gene polymorphisms in high myopia

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Purpose: This study is to investigate the genetic association of high myopia trait with the hepatocyte growth factor (HGF) gene, a potential candidate predisposing to myopia onset and development.

Methods: We have identified single nucleotide polymorphisms (SNPs) through the HGF gene region using denatured high performance liquid chromatography technique and established the linkage disequilibrium pattern in a Chinese population ($n = 150$). Then the tag SNP markers were selected and genotyped using restriction digestion and fluorescence polarisation assays for 128 nuclear families with 133 severely myopic (mean spherical equivalent, MSE £-10.0 diopters) offspring. The family-based association study (FBAT) was performed using FBAT1.5.5 and genotype relative risk (GRR) was calculated using GENASSOC software.

Results: Among the 18 SNPs identified, nine were common and one haplotype block with a 'hole' SNP inserted was defined. Three SNPs were selected as tag SNPs for association study. The marker HGF5-5b located in the upstream region was found associated with high myopia considered as a quantitative trait MSE (Offset = 0) under additive, dominant and recessive models ($p = 0.0157$, 0.0108 and 0.0108, respectively). The GRR was 2.19 for the genotype C/T, and 2.14 for T/T with reference to C/C of HGF5-5b. Multi-locus analysis showed significant association at some haplotype combinations even after correction for multiple comparisons. Similar results were also obtained with high myopia considered as a qualitative binary trait (Affected or unaffected).

Conclusion: Our study provided an LD pattern in the HGF locus in a Chinese Han population and supports the hypothesis that the HGF gene might be associated with high myopia. In particular HGF5-5b seems to be an important marker which was always implicated in the significant findings.

F022

Identifying the genetic components to refractive error and ocular biometrics – a twin study

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Purpose: To investigate the genetic component of refractive errors and ocular biometrics using a classical twin design.

Methods: All twins currently living in Victoria aged 18 years or greater and of both genders were invited to participate through the Australian Twin Registry. Each subject underwent a general questionnaire, anthropometric assessment, vision examination, cycloplegic refraction, ocular biometric assessment, slitlamp examination and individual blood samples were obtained via venepuncture. Myopia was defined as –0.5 DS or worse in either eye.

Results: A total of 612 twin pairs aged between 18–88 years were examined. Myopia prevalence was approximately 25% in this twin cohort. Intra-pair correlations for spherical equivalent (SE) were significantly higher in MZ twin pairs ($r = 0.82$) compared to DZ twin pairs ($r = 0.36$), ($p < 0.01$). Intra-pair correlations for ocular biometric measures were also significantly higher ($p < 0.01$) in MZ twin pairs compared to DZ twin pairs. Heritability estimates ranged from 50% in males for corneal astigmatism to over 90% in axial length. Heritability estimates for spherical equivalent were 88% and 75% in males and females respectively, where additive genetic effects explained the majority of the variance (males = 58%, females = 47%).

Conclusion: The myopia prevalence found in this twin study is comparable to that found in the general population. Genetic factors, both additive and dominant, play a significant role in refractive error (myopia and hypermetropia) as well as in ocular biometrics, particularly axial length. The sex limitation ADE model provided the best-fit genetic model for all parameters.

F023

Genes in myopia (GEM) study: heritability estimates and linkage analysis results

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Purpose: To examine the heritability of Spherical Equivalent (SphE), axial length (AL), anterior chamber depth (ACD) and corneal curvature (CC) and to identify genetic linkage associated with common myopia in families collected through the Genes in Myopia (GEM) study in Australia.

Methods: A total of 290 myopic probands (SphE£ –0.50 D in both eyes) with a family history of myopia were recruited. An additional 575 individuals recruited from the proband's families were also examined. All individuals underwent a detailed eye examination including ocular biometric measurements using an IOL master, completed a risk factor questionnaire and had a blood sample taken. Univariate heritability estimates were derived using SOLAR 2.1 with proband ascertainment correction. Genome scan on three of the largest pedigrees and 42 controls was performed by the Australian Genome Research Facility, using the ABI Prism Linkage Mapping Set Version 2 (PE Applied Biosystems) with 400 markers at ~10 cM coverage. Linkage analysis was performed using Merlin v0.10.1.

Results: Eighty-two pedigrees (636 individuals) were available for this study. The pedigrees contained 3–38 family members with 1–18 myopic members. The mean age of subjects was 45 (range 5–92). The mean (±SE) of SphE was –0.55 ± 0.13 D, AL was 25.76 ± 0.12 mm, ACD was 3.50 ± 0.03 mm and CC was 42.04 ± 0.18 D. The heritability estimates (±SE) for R SphE was 0.40 ± 0.06, RAL was 0.45 ± 0.06, RACD was 0.73 ± 0.08, and for RCC was 0.15 ± 0.05. All heritability estimates differed significantly from zero. Multipoint parametric HLOD of 4.02 and non-parametric linkage (NPL) score of 2.37 was observed.

Conclusion: There were significant heritable components of the variances of SphE, axial length, anterior chamber depth and corneal curvature. Furthermore axial length had the highest estimated heritability. A significant linkage was identified to be associated with common myopia.

F024

Hepatocyte growth factor receptor association with myopia in the Singapore cohort study of the risk factors of myopia (SCORM)

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Purpose: In Singapore both incidence and progression rates of myopia are extremely high, and relatively large proportion of phenotypic variance remain unaccounted for by environmental factors alone. The hepatocyte growth factor (HGF) receptor is present in all three layers of the cornea and is important in cellular proliferation, differentiation and migration. We aim to evaluate the association between HFG receptor and change in refractive error.

Methods: A community-based non-related case control association study was performed in a cohort of 696 Singaporean

Chinese children, aged between 10 to 12 years from the Singapore Cohort Study of the Risk Factors of Myopia (SCORM). Eleven single nucleotide polymorphisms (SNPs) were genotyped in the HGF receptor using the Sequenom Mass-Array genotyping platform and analysed for association with disease.

Results: Polymorphisms within the HGF receptor were found to be significantly associated with both overall myopia and change in refractive error. For myopia in general, the variant allele of three SNPs (SNPs 11, 4, and 5 respectively) was observed to be significantly over-represented in myopic children compared to non-myopes ($2 \times 2\chi^2 = 8.10$, $p = 0.004$; $2 \times 2\chi^2 = 4.30$, $p = 0.038$; and $2 \times 2\chi^2 = 3.52$, $p = 0.061$). Further analysis revealed the variant allele of all three SNPs to be associated with progression of refractive error over a period of 3 years. ($p_{for\ linear\ trend} = 0.014$, 0.033, and 0.019 respectively). Comparisons between the best (1st) and the worst (4th) quartiles for progression of refraction also revealed the variant allele to be over-represented in children with rapid progression of refractive error: $p = 0.004$, $p = 0.024$, and $p = 0.034$ for SNPs 11, 4, and 5 respectively.

Carriage of the variant allele of these three SNPs also correlated with an increased mean progression of refractive error compared to children who are wild-type for the polymorphisms ($p = 0.034$, $p = 0.050$, and $p = 0.010$ respectively, analysis by one-way ANOVA).

Conclusion: Our data implicate the possible involvement of HGF receptor in the pathogenesis of myopia in general, as well as overall progression of myopia. These results complement the recently described association of HGF with myopia, and underline the importance of eye growth genes in the development of common myopia.

F052

The prevalence of myopia in Danish conscripts from 1882 to 2004

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Purpose: To determine the prevalence of myopia among Danish conscripts and compare the results with similar Danish studies from 1882 and 1964. Further to analyse the relation between myopia and educational level, ethnicity, intelligence (IQ), body mass index (BMI) and height.

Methods: A cross-sectional study based on case reports from 4681 male conscripts. The following data were collected from September to December 2004; age, place of birth, weight, height, power of spectacles or contact lenses (CL), visual acuity, number of school years (8–13 years), occupation, intelligence test (IQ-test) score and ethnicity.

Results: The prevalence of myopia (≤ -0.25 D, spherical equivalent) was 12.9% (95%CI (confidence interval) $\pm$ 0.96) compared to 14.5% in 1964 and the prevalence of high myopia (< -6.5 D) was 0.3% (95%CI $\pm$ 0.15) compared with 0.6% in 1964. Myopes scored higher (45.27 (SD 9.38)) on IQ-tests than emmetropes (41.35 (SD 10.37)) ($p < 0.001$). Ethnicity played no significant role in the degree or the frequency of myopia. No relation was found between myopia and BMI or height.

Conclusion: The prevalence of myopia (≤ -0.25) and high myopia (< -6.5D) among male conscripts in Denmark has decreased significantly since 1964. Educational length and IQ-test score were related to myopia whereas ethnicity, BMI and height were not.

Poster Papers

P001

Differential protein expression in form deprived chick retina

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Purpose: To identify the differential protein expressions in form deprived myopic chick retina using proteomics approach.

Methods: Right eyes of the two- day old chicks were attached with dark goggles for 3 days to induce form deprivation myopia and the corresponding left eyes were served as controls. The refractive errors of the eyes were obtained by using retinoscopy before and after the treatment. The retinal tissues were harvested and frozen in liquid nitrogen. Samples were homogenised in a dismembrator to extract soluble proteins. Protein profiles were generated by two-dimensional gel electrophoresis (2-DE) and the protein spots in the 2D gel were visualised by silver stain followed by image analysis using the ImageMasterTM 2D Platinum Software. The differentially expressed protein spots were excised and in-gel digested with trypsin. The protein masses of the digested peptides were studied by MALDI-TOF Mass Spectrometry (MS). The proteins were then identified by peptide mass fingerprinting with the Mascot database.

Results: Software analysis showed strong similarity in the protein profiles between the treatment and control eyes. From the 2DE protein maps, one protein spot was found up-regulated while another one was found down-regulated in the gels of form deprived retina. These two protein spots were later successfully identified as destrin (up-regulated) and apolipoprotein AI (down-regulated) by MALDI-TOF MS.

Conclusion: The mechanism of compensated myopia in form deprivation could be studied using a proteomics approach. According to the protein databases, destrin promotes cytoskeleton dynamics such as cytokinesis (cell division) and cell motility while apolipoprotein AI promotes cholesterol efflux from tissues. The up regulation of destrin might indicate the accelerated growth rate of retina in form deprived eye while the down regulation of apolipoprotein AI might retain the cholesterol in retina of form deprived eye. Further investigation is needed for the understanding of the differential protein expressions in response to the compensated retinal growth.

P002

A graft for scleroplasty made of metal with shape memory: an experimental study

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Purpose: The purpose of this work was to develop an artificial biocompatible graft for the surgical support of staphilomatous sclera in highly complicated myopia, which had to be non-traumatic and easy to implant, and to ensure a sustained level of compression over a long period of time.

Methods: To achieve this goal, we designed a 'dynamic graft' of titanium nickelide. This inert alloy, compatible with living tissues, has a shape memory effect, which means that it remembers the shape it received originally and restores it in situ with the increase of temperature to 39–420°C when heated externally. Two dynamic graft varieties were designed; one was shaped as a perforated plate and the other originally had the shape of a flattened spiroid spring. Experimental scleroplasty using these dynamic grafts was performed on 20 chinchilla rabbit eyes, which were examined by clinical and ultrasonic methods at different times after the surgery and then enucleated and studied histologically.

Results: A morphologic and ultrasonic study of experimental eyes taken after scleroplasty with these grafts revealed the presence of a connective-tissue capsule around the graft, a local impression of the sclera in the area of the graft projection, and a reduction of the axial length of the eyeball.

Conclusion: The proposed method enables the weakening of the tension of the shells in the posterior pole area and improves the contact of choriocapillaris, pigment epithelium and Bruch's membrane. This may affect favorably their metabolism, create the conditions for blocking microdefects in Bruch's membrane and suppress the newly formed vessels. The experimental study validates the recommendation of the designed transplants for further experimental and clinical studies.

P003

A role for inward-rectifying potassium channel (Kir4.1) during refractive compensation to optical defocus

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Purpose: An important function of Mueller glial cells is the spatial buffering of extracellular K+ which is thought to be mediated by the predominant K channel expressed on Mueller cells -the inward rectifying channel (Kir4.1). In the mammalian retina, Kir4.1 potassium channels are typically found to be co-localised with the specialist water channels, aquaporin AQP4, and have been postulated to influence the osmotic environment leading to rapid cellular water movements during light–dark transduction. As we have previously shown (ARVO 2005 and 2006) AQP4 expression is associated with the development of myopia we now predict that Kir4.1 will also be differentially expressed during the induction of myopia and hyperopia.

Methods: Thirty chickens were raised from Day 5 with +/−10 D lenses, which were removed following various durations of visual experiences (t = 24, 48, 72, 96 or 120 h). Biometric measurements of refractive errors were performed prior to sacrifice. Frozen transverse sections of retina were prepared for immunohistochemistry using rabbit anti-rat polyclonal Kir4.1 primary antibodies and fluorescent anti-IgG secondary antibodies.

Results: All eyes with lenses developed refractive errors and ocular growth appropriate to the sign of defocus. Immunohistochemistry revealed enhanced expression of Kir4.1 localised primarily to the inner plexiform layer with comparatively lower expression in the ganglion cell layer. Kir4.1 expression was present within 24 h of the initiation of optical defocus. Differential expression of Kir4.1, which was evident early in the induction phases of myopia and hyperopia, was reduced as compensation to lenses became apparent.

Conclusion: These results suggest that Kir4.1 channels on Mueller cells are likely to play a role in the morphological changes seen during the induction of myopia and hyperopia by regulating glial uptake of K (+) released during neuronal activity.

P004

Atropine injections up-regulate ZENK expression – but only in retinas responding to form-deprivation

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Purpose: The retinal expression of the immediate-early gene ZENK is altered during the early stages of form-deprivation myopia in the chicken. The current study analysed the effect of

atropine injections on ZENK mRNA expression during the first hour of form-deprivation.
Methods: Animals were anaesthetised with isoflurane before 10 μL of either atropine (25 mM in the needle) or a vehicle control (distilled water) was injected into the vitreous chamber of the left eye, 1 h prior to form-deprivation. Following injection, both injected and non-injected animals were form-deprived for 1 h. Five samples were collected from each group, with each sample containing two retinas, one from each of two animals. Total RNA was extracted using TRIZOL following the manufacturer's protocol. ZENK mRNA levels were determined by real time RT-PCR. Results were normalised against β-actin. Percentage changes in mRNA expression were calculated by the formula of Pfaffl, 2001 (Pfaffl, Nucleic Acids Res; 2001: 29, e45).
Results: Following 1 h of FDM, ZENK mRNA levels in the chicken retina were reduced by approximately 55%. The injection of atropine before the initiation of form-deprivation not only prevented the suppression of ZENK expression, but in fact induced an increase in ZENK mRNA levels by approximately 30%. In control retinas, atropine injections had no effect on ZENK expression.
Conclusion: ZENK mRNA levels in the chicken retina were significantly down regulated after 1 h of FDM. In contrast, ZENK expression became elevated in the eyes of chickens treated with atropine prior to form-deprivation. Atropine injection had no effect on ZENK expression in control retinas. This suggests that atropine acts directly and rapidly on retinal circuits early in the signaling process, to mimic the effects seen when eye growth is slowed by myopic defocus, but only in retinas responding to form-deprivation.

P005

Modulating myopia; environmental and pharmacological investigations of the neuroscience of refractive compensation

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Purpose: We have previously shown that refractive compensation to both positive and negative optical defocus can be disrupted by altering the balance of the ON/OFF systems whether by use of low frequency (1–4 Hz) temporal luminance modulation (LFTLM), pharmaceutical perturbation with L-alpha Amino Adipic Acid (LAAA), a gliotoxin which acts to inhibit the b-wave of the ERG, or by Bumetanide, a specific inhibitor of the Na-K-2Cl cotransporter of the RPE. What has not been established is the retinal level at which this refractive compensation is initiated.
Methods: Chicks were reared from day 5–10 wearing monocular +/−10 D lenses or no lenses, under diurnal light conditions or LFTLM of 1 Hz from 1.8–183 lux, after a 5 μL intravitreal injection of either 1 mM Bumetanide or 0.5 M LAAA, or PBS control. Drugs were dissolved in PBS carrier. Retinoscopy and A-scan ultrasonography was performed to access refractive state and axial dimensions at the end of the experimental period.
Results: Significant interaction between Drug, Lens and Light conditions was observed for measures of refractive state ($p < 0.01$). LAAA did not prevent the myopic shift previously reported following rearing LFTLM conditions for either +/−10 D groups. Bumetanide inhibited refractive compensation and ocular growth to −10 D lenses but allowed compensation to +10 D lenses in the presence of LFTLM. Changes seen in refraction were also apparent in measures of axial dimensions, notably reflected by posterior eye growth, but also with contributions from the anterior chamber.
Conclusion: In general the myopic shift to optical defocus previously observed following LFTLM was inhibited by bumetanide but not by LAAA. These results indicate that targeted modification of RPE function, but not inhibition of ON-bipolars, play a major role in the development of refractive error and ocular growth in response to LTFLM.

P006

Muscarinic acetylcholine receptors (mAChRs) are involved in regulation of sclera fibroblast proliferation with experimental model of myopia

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Purpose: To investigate the effect of muscarinic toxins (MTs) and conventional antagonists (atropine or pirenzepine) with experimental models of myopia and to confirm the presence of mAChRs on mouse scleral fibroblasts (SFs).
Methods: The procedures for experimental myopia were applied in Balb/cJ mice by placing a negative (−10) contact lens over the right eyes (OD) of 90 mice ($n = 30$ in each group, 3 repetitions) for eight weeks. Left eyes served as controls (OS). SFs were cultured from control and myopic eyes and used at passage 2–4. Proliferation studies using BrdU were carried out with atropine and pirenzepine at 0, 0.1, 1, 10 and 100 μM, and MT3 at 0. 0.4, 0.8, 1.6, 3.2 μM. Agonists MT1, MT2 and carbachol were used at 0, 0.4, 0.8, 1.6, 3.2 μM, and 0, 0.1, 1, 10, 100 μM respectively.
Results: Axial length of lens treated eyes was 111% of their controls. Refractive error of lens treated eyes was –3D ± 0.08, of their controls + 7.5D ± 0.10. BrdU incorporation after treatment with atropine, pirenzepine or MT3 was compared with non-treated controls. These drugs inhibited DNA synthesis in SF from non-myopic and myopic eyes in a dose dependent manner ($p < 0.05$, ANOVA, $n = 4$). In contrast, BrdU incorporation of SF from non-myopic and myopic eyes were found to increase in a dose dependent manner with carbachol, MT1 and MT2 ($p < 0.05$, ANOVA, $n = 4$). Atropine was able to block the effect of carbachol when SFs were pre-treated (3 h) with an equimolar amount of atropine.

Conclusion: Our results suggest muscarinic receptors exist in mouse SF and are involved in the regulation of cell proliferation. Their effects may be mediated through the G-protein liked receptor on the SF membrane.

P007

Muscarinic mechanisms in a mouse model of myopia

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Purpose: To determine if the regulation of muscarinic receptors (mAChRs) m1–m5 in scleral fibroblasts is changed during the development of experimental myopia in the mouse.

Methods: Experimental myopia was induced by lid-suturing and by placing a −10 D contact lens over the right eyes of 200 mice. An additional 10 mice were used as controls by placing a Plano contact lens. RT-PCR and northern blot was carried out using specific primers for m1-m5 and products sequenced. Real-time PCR was used to quantify message levels. Axial length was measured by video image photography or the AC-Master, OLCI (Carl-Zeiss) and refraction was measured by retinoscopy. Plastic embedded tissue was used to quantify scleral thickness.

Results: Axial length of lens-induced myopic eyes was 111% of their controls and 103% of controls after atropine treatment and lid-sutured myopic eyes was 107% of their controls. Refractive error of lens treated eyes was −3D ± 0.08, of their controls +7.5D ± 0.10 and +1.5D ± 0.09 after atropine treatment. Scleral thickness increased from anterior (16.7 ± 0.02 μm), equator (41.7 ± 0.01 μm) to posterior (91.7 ± 0.03 μm) in control eyes. In myopic eyes, sclera was similar at anterior (16.7 ± 0.01) but thinner at equator (33.3 ± 0.01 μm) and posterior (58.3 ± 0.02 μm). Immuno-histochemistry, RT-PCR and Northern blots showed expression levels of all five mAChRs. Real-time PCR showed that message levels for atropine treated eyes compared to controls were as follows: m1 and m3 increased (125%, and 113%, respectively) and m4 (112%), genes were up regulated in atropine treated myopic sclera and m2 and m5 showed little change.

Conclusion: This study shows that mice require 6 weeks to develop measurable myopia. It confirms that muscarinic receptor sub types; m1–m5 are present in mouse sclera and that atropine may act on one or more mAChRs to differentially regulate expression levels of specific receptors.

P008

Nature of astigmatism associated with experimentally induced myopia or hyperopia in chickens

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Purpose: Astigmatism is a very common refractive error in humans but its etiology is poorly understood. Recent studies in monkeys indicated that visual conditions known to alter axial eye growth also promote the development of astigmatism. This study aimed to characterise the astigmatism that is associated with experimentally-induced axial ametropias in chicks.

Methods: Longitudinal (L) and cross-sectional (C) data were obtained from chicks that were raised under four different visual manipulations known to induce axial ametropias: monocular form deprivation by translucent diffusers (L = 8; C = 11), monocular spherical defocus by −10 D (L = 9; C = 10) or +10 D lenses (L = 11; C = 11), and constant light (L = 10; C = 10). The visual manipulations began at 5 days of age and continued for a week. Age-matched groups raised without any treatment served as control groups (L = 11; C = 10). Refractometry (Hartinger) without cycloplegia was performed for all birds and keratometry (Infrared photokeratometry) was performed for a subset of birds at the end of the treatment period.

Results: Significant amounts of astigmatism were associated with experimentally induced spherical ametropias throughout the treatment period. At the end of the 7-day treatment period, sixty-eight of the 80 treated chicks exhibited refractive astigmatism >1.2 D (85%), whereas none of the 21 control chicks had astigmatism >1.1 D (mean ± SD = 3.5 ± 2.7 D vs 0.2 ± 0.3 D; $p < 0.0001$). The refractive and corneal astigmatisms (>1.2 D) in the treated eyes were predominantly against-the-rule (72% and 83%, respectively; range = 60–120 deg). In addition, the magnitude of anisometropia was significantly correlated ($p < 0.01$) with the magnitude of either refractive ($r = 0.5$) or corneal astigmatism ($r = 0.3$). The components for refractive and corneal astigmatism (total astigmatism, J0 & J45) were all significantly correlated with each other ($r = 0.4$–0.7; all $p < 0.003$).

Conclusion: The nature of astigmatism associated with spherical myopia or hyperopia in chicks is similar to those reported in humans in many respects, suggesting that vision-dependent changes in eye growth may contribute to the astigmatism commonly found in humans.

P009

Proteome analysis of myopic chick sclera

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Purpose: To study the differential protein expression of sclera in myopic chick eyes using proteomic approach and to explore the biochemical mechanisms of growth in sclera underlying myopia development.

Methods: Ten-diopter lens (−10 D) and Plano lens were mounted in front of right and left eyes respectively on 2-day-old chicks for 3 days. After 3 days of –10 D lens wear, the refractive errors of the eyes were determined. Sclera was harvested and the scleral proteins were extracted with detergent cocktail. The protein extract from sclera were separated by 12% continuous gels at pH 3-10 using fluorescent 2-dimensional differential in-gel electrophoresis (2D-DIGE).

Biological variations of the protein expression level were analysed with DeCyder software. Protein spots were then visualised with sliver staining.

Results: Those differentially expressed protein spots were excised from the gel and digested with trypsin. Peptide masses of the protein digest were identified by Matrix Assisted Laser Desorption Ionisation-Time of Flight (MALDI-TOF) mass spectrometry. After analysis by DeCyder software, 22 proteins were found to be expressed differentially (at least 1.2 fold difference) in myopic chick sclera. Ten of them were successfully identified by MALDI-TOF mass spectrometry. Prolyl−4-hydroxylase (AA 5–494) was one of the up-regulated proteins found in myopic chick sclera, which played a central role in biosynthesis of collagen.

Conclusion: We have profiled the proteins that differentially expressed in myopic chick sclera using 2D-DIGE. These may shed important light on the regulation of ocular growth in myopia. In particular, enzymes involved in biosynthesis of collagen gave us clues in biochemistry of scleral remodeling during myopia.

P010

Synthetic grafts with specified properties for sclera reinforcement treatment of progressive myopia

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Purpose: In progressive myopia, scleroplasty contributes to its stabilisation and lesser incidence of eye fundus complication (E.P.Tarutta, 2004). The efficiency of such interventions may be increased by using new-generation artificial sclera reinforcement materials with specified biological properties, in particular, those stimulating collagen formation and improving hemodynamics in myopic eye shells. Purpose: to study experimentally morphological, biochemical, and biomechanical parameters of scleroplasty using biologically active cellular-structure polymer-coated knitted polyether implants with deposited germanium-containing preparation on the basis of selected Ginseng strains and to evaluate clinical results of such scleroplasty.

Methods: Thirty-two rabbit eyes enucleated after scleroplasty were studied by histological and histochemical methods and by differential scanning calorimetry (DSC). Additionally, the sclera was tested for amino-acid composition, GAG level, and stress/strain parameters. Clinically, bandaging scleroplasties or low-invasive sclera strengthening interventions were administered to 44 patients (44 eyes) aged 9–26 with progressive myopia of 5.0–15.0 D and average annual progression of 1.3 D. Twice yearly, all patients were given visual tests, autorefractometry, and ophtalmoscopy. Anterioposterior axes (APA) and relative accommodation reserves (RAR) were measured.

Results: The morphological study shows intensive engraftment and tight fusion of the implant with the sclera. Biochemical and thermomechanical analysis revealed the resemblance of the capsule around the implant to intact sclera. It mainly consists of collagen I whose fibers have regular structure and enough cross-links to ensure normal thermomechanics. DSC helped detect the collagen fraction with thermomechanical 'immature' crosslinks in capsules around the implant, which is explained by increased synthetic fibroblast activity caused by Ginseng preparation.

Conclusion: Clinically, the material ensured myopia stabilisation for 1 year in 93.5% cases. In 6.5% cases, annual progression rate showed a 2.6-fold decrease. 37 eyes (84%) showed myopia reduction by 0.25–0.75 D. APA remained stable and RAR rose by 0.5–3.0 D in all cases, which is evidently due to the stimulation by the implant.

P011

The effect of induced myopia on ocular compliance in the guinea pig: a role for scleral contractile cells?

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Purpose: (1) Determine the effect of induced refractive error on ocular compliance in the guinea pig. (2) Confirm the presence of contractile cells in guinea pig sclera.

Methods: One-week-old guinea pigs ($n = 19$) were monocularly deprived of form vision (FD) for 14 days. Refractive error measures were taken under cycloplegia with an IR Optometer. Ocular compliance (change in length/mmHg change in IOP) was compared between the FD and control eyes of four anaesthetised animals. 15 MHz A-scan ultrasound measures were taken every 10 min with IOP increased to 100 mmHg for one hour. Further ultrasound measures were taken 20 min after returning the IOP to 15 mmHg. Immunocytochemistry with antibodies to α-smooth muscle actin (α-SMA) and smoothelin was used to determine the presence of contractile cells in guinea pig sclera.

Results: FD induced -4.54 ± 1.86 D of myopia, which was correlated with 185 ± 244 μm of vitreous chamber depth (VCD) elongation ($n = 19$; R2 = 0.36). There was a significant increase in the VCD after one hour of raised IOP in the deprived eye only ($p = 0.004$), while the control eye remained similar in length to baseline ($p = 0.165$). After reducing the IOP to 15 mmHg from 100 mmHg there was a significant shortening of the VCD in the control eye ($p = 0.015$) but not in the deprived eye ($p = 0.209$). Cells displaying the contractile markers α-SMA and smoothelin were identified in guinea pig sclera.

Conclusion: In the guinea pig increasing IOP causes VCD elongation in FD eyes, but not in control eyes. On subsequent reduction of IOP a decrease in the VCD is observed in the control but not the deprived eye. Contractile cells are present in guinea pig sclera.

P012

Evaluation of different spherical equivalent cut-offs to define myopia

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Purpose: To determine the optimal spherical equivalent cut-off for defining myopia.

Methods: A cross sectional study of 1334 Chinese schoolchildren without astigmatism or hyperopia (aged 7–9 years) was recruited in the Singapore Cohort study Of the Risk factors for Myopia (SCORM). Uncorrected distance logMAR VA was measured for both eyes. Autorefraction was performed after the instillation of 3 drops of 1% cyclopentolate at 5 min apart. SE cut-off points [−0.25 Diopters (D), −0.5 D, −0.75 D, −1.0 D] were evaluated.

Results: Using different SE cut-off points, the prevalence rates of myopia varied from 45.8% (SE at least −0.25 D) to 30.7% (SE at least −1.0 D). The cut-off of at least −0.75 D had a sensitivity and specificity of 91.8% (95% CI 89.2–94.4) and 93.7% (95% CI 92.1–95.3), respectively to predict visual impairment defined as uncorrected logMAR VA > 0.3 (worse eye myopia). The next best cut-off of −0.5 D had a higher sensitivity (93.3%), but lower specificity (87.9%). The criteria of −0.25 D and −1.0 D have unacceptably low specificities (80.1%) and sensitivities (86.7%), respectively.

Conclusion: The cut-off points of −0.5 D and −0.75 D in SE refraction are appropriate for the prediction of uncorrected VA worse than 0.3.

P013

Comparisons of the handheld autorefractor, table-mounted autorefractor, and subjective refraction in Singapore adults

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Purpose: To compare the Retinomax autorefractor with the table-mounted autorefractor and subjective refraction in Singapore adults.

Methods: Adults (n = 100) attending a tertiary eye hospital clinic were examined by a trained optometrist. First, subjective refraction testing was performed using a trial lens set, followed by hand-held autorefractor tests using the Nikon Retinomax and the table-mounted autorefractor (Topcon RM8000B). Spherical equivalent and vector components of astigmatism were analysed: J0 (Cartesian astigmatism) and J45 (oblique astigmatism).

Results: The Retinomax autorefractor readings (mean = −4.69 Diotpers) were more minus compared with the table-mounted autorefractor (mean = −4.05 Diopters) and subjective refraction (mean = −3.90 Diopters). There were significant differences in J0 and J45 for comparisons between subjective refraction and Retinomax autorefraction, and table-mounted autorefraction and Retinomax autorefraction.

Conclusion: The Retinomax autorefractor measures were more minus compared with the table-mounted autorefractor and subjective refraction. The Retinomax autorefractor is not recommended for research purposes, unless in remote inaccessible areas where a portable instrument is necessary and cycloplegia is not possible.

P014

Can the trend of increasing myopia prevalence be prevented? — Taiwan experience

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Purpose: There has been an increasing tendency of the prevalence and severity of myopia among school children in Taiwan over the past 20 years [reference: Ann Acad Med Singapore 2004; 33:27–33]. This study is to evaluate the outcome of National Myopia Prevention Programme executed on preschool and early school-agers.

Methods: An island-wide refract ional survey was carried out in 2000. The sampling technique involved multi-stage stratified systematic clusters with random samples. There were 41 primary schools with 55 hundred children sampled in 2000. Meanwhile a five-year National Myopia Prevention Program was initiated in 1999. And the same 41 schools were revisited in 2005 with 70 hundred children re-sampled and examined. The cycloplegic refractive status was measured by an autorefractor, and was re-checked by the same ophthalmologists with retinoscopy.

Results: In 2000, the prevalence rate (right eye) of myopia among first-graders was 20.4%, increasing to 60.6% at age 12; while in 2005, the figures were 21.3% and 63.1% respectively. Myopisation is still very young. In 2005, the mean ocular refraction became myopic at age 8, the same as year 2000, and the same with either sex.

*Conclusion:*The prevalence of myopia in Taiwan was reported increasing year by year before. Recently, the personal computers are more popular everywhere and the parents ask their children more strictly due to the less birth rate. On the other hand, our government provides a lot of strategies such as less homework, enough light while studying, trying to reduce the incidence of school-myopia children. This latest survey reveals that the trend of increasing myopia prevalence seems to be dampened.

P015

Prevalence of myopia and refractive errors for the Korean students

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Purpose: There has not been detail data about the myopia for Korean students so far. This study aims to investigate prevalence of myopia and refractive errors for Korean students.

Methods: A total of 2617 students, 1328 students from city area schools and 1289 students from rural area schools (man: 1394, women: 1223) in Korea were participated. Non-cycloplegic refractive error measurements were carried out using Vision-K (Shinnipon). The age range of participants was from 7 years old, which is first year of primary school, to 18 years old, which is 3rd year of high school students. The myopia was identified over –0.50 D of equivalence spherical refractive error.

Results: Prevalence of myopia increased 25.33 %(rural: 48.3, city: 14.9) for 7 years old to 83.19 %(rural: 80.0, city: 87.6) for 18 years old in both areas together. Refractive errors were higher for rural area students (7y: -0.59 ± 1.28 D, 8y: -0.92 ± 1.07 D 9y: -0.80 ± 1.32 D) than for city area students (7y: 0.07 ± 0.81D, 8y: -0.20 ± 1.20D 8y: -0.41 ± 1.21 D) ranged 7–9 years old (independent t test, $p < 0.05$). In over 13 years old, refractive errors appeared to be a little higher for city area students than rural area students but the difference between two groups was not statistically significant. The average refractive errors of both groups increased -0.25 ± 1.28 D for 7 years old to -2.88 ± 2.32 D for 18 years old.

Conclusion: Myopia prevalence in Korea was also very high as much as in other Asian countries such as Hong Kong, Taiwan, and Japan. The reason for higher myopic prevalence and power among younger students in rural areas compared with city students may be due to lower parental concern about vision in rural areas, and consequent absence of correction or under-correction of myopia.

P016

The Aston eye study: methodology for a population-based study of myopia in UK urban school children

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Purpose: To describe the methodology of the Aston Eye Study (AES), a 3-year prospective cross-sectional study, starting October 2005, this will determine the prevalence of refractive error in a large sample of UK school children. The recruitment of children from a large metropolitan area having diverse educational and ethnic backgrounds will facilitate evaluation of recent reports highlighting the significant role of urbanisation and education in the prevalence of myopia.

Methods: The target population for the AES has been identified by random cluster sampling of schools in the West Midlands area that have been stratified for both socioeconomic index of specific sub-areas and ethnicity. To encompass onset and development phases of child myopia two separate samples are currently being examined over the study period: 1,700 aged 6/7 years and 1,200 aged 12/13 years. All procedures requiring informed consent (parents) and assent (children) have been approved by the Aston University Ethical Committee. An 89-item parental questionnaire and 78-item child questionnaire include sections that address potential risk factors and gene-environment interactions related to myopia: e.g. family history of spectacle wear, education, nutrition, ethnicity and lifestyle.

Results: Examinations include: assessment of visual acuity; cover test for oculomotor status; non-contact ocular biometry (i.e. axial length, corneal radius of curvature and anterior chamber depth using IOLMaster Zeiss, Jena, GmbH); cycloplegia (proxymetacaine 0.5%:cyclopentolate 1%); binocular open-field autorefraction (Shin-Nippon SRW5000, Japan) and measures of height and weight. The initial stages of data collection ($n = 87$) and protocols have been well received by both parents and children and without any adverse incidents or effects.

Conclusion: To date, the AES design and methodology appears sufficiently robust, comprehensive and accessible to provide a valuable database for the target population. The standardised protocols used will, for the first time in over 40 years, allow comparison of UK data with other international population-based data.

P017

The prevalence of myopia and variables that can affect it

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Purpose: To study the prevalence of myopia and variables that can affect it such as age, sex, race, close work, the beginning myopia age, hereditary of refractive error, wearing glasses or contact lenses, and eye degree in the first examination.

Methods: During 12 months (July 2004–July 2005) 465 patients were selected randomly from who came to our clinic. 210 cases had myopia and 202 were selected as witness group. The patients' eyes were examined by using the Nidek 8000 autorefractometer and the information about age, sex, race, education, habits of study and work, hereditary background and the age of beginning myopia were recorded in the tables.

Results: Prevalence myopia was 45% in the patients. There was meaningful relation between sex and myopia $p = 0.000$ (64.6% of them were female) and there was meaningful relation between myopia and close work, education, hereditary background, $p = 0.001$, but there wasn't any meaningful relation between myopia and other variables. The average age in myopia group was 36.32 and in witness group was 35.12 that

showed no significant relation between two groups' age. 88.9% of patient with myopia had also astigmatism.
Conclusion: The prevalence of myopia among the studied patients was 45%. This study showed that sex, close work, hereditary background and education affected on myopia, however the race, related disease, time of eye examination didn't affect the myopia.

P018

Refractive and biometric changes in a university student population over two years

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Purpose: To determine the pattern and rate of myopia progression and biometric change in a population university students.
Methods: Non-cycloplegic autorefraction (Topcon KR3500), corneal curvature (K), anterior chamber depth (ACD) and axial length (AL) (Zeiss IOLMaster) were measured at 30-day intervals during term time over two years in fifty students mean age 21.37 ± 5.53 years.
Results: AL elongated by 0.131 ± 0.112 mm and 0.132 ± 0.101 mm in the right and left eyes respectively for myopes and 0.064 ± 0.080 mm and 0.073 ± 0.058 mm in the right and left eyes respectively for emmetropes. The subjects were classified into two groups dependant on degree of AL elongation: group 1, elongation < 0.1 mm and group 2, elongation > 0.1 mm over two years. Both groups included emmetropes and myopes. The average rate of AL elongation during the study period in group 1 was 0.017 mm year^{-1} and 0.019 mm year^{-1} right and left eyes respectively and 0.071 and 0.064 mm year^{-1} right and left eyes respectively for group 2. The mean myopic shift in refraction for group 1 was 0.036 ± 0.153 D and 0.021 ± 0.115 D for right and left eyes respectively, and group 2 was 0.333 ± 0.349 D and 0.428 ± 0.338 D, right and left eyes respectively. There was no significant change in K or ACD.
Conclusion: AL elongated with time and myopic eyes elongated more than emmetropic eyes over the study period. Refractive errors tended to shift towards myopia, which was supported by elongation of axial length. The rate of axial elongation is not a constant and varies both between subjects and within time.

P019

Correction of childhood myopia in Singapore

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Objectives: Uncorrected refractive error is a leading cause of visual impairment. We report the prevalence rate of uncorrected childhood myopia and its associated risk factors in Singapore, a developed country with one of the highest myopia rate in the world.
Methods: Two separate cross-sectional studies of 1979 Singapore school children aged 7–9 years and 629 school children aged 13 years were conducted. Refractive data collected included logMAR acuity and autorefraction. Children with habitual visual acuity of logMAR 0.2 or worse underwent subjective refraction and were assessed for best corrected visual acuity. Myopia was defined as spherical equivalent of −0.50 D or worse. The odds ratio and 95% confidence interval (CI) for uncorrected myopia were calculated for age, gender, race, socioeconomic status, rate of myopia progression and parental myopia.
Results: The prevalence rate of uncorrected myopia in the children aged 7–9 years was 10.8% (95% CI 9.4% to 12.1%). In the 13 year olds, the rate was 22.3% (95% CI 19.0% to 25.5%). The odds ratio for uncorrected myopia in the 7–9 year olds were significantly higher in children who were younger, who had myopia progression of −0.50 D or more in the past year, and whose parents were not myopic ($p < 0.05$). In the 13-year-old children, no risk factors were significant.
Conclusion: Uncorrected myopia is a significant problem among Singapore school children and current public health measures aimed at correcting visual impairment from myopia in these children appear inadequate.

17 August 2006, Thursday – Day 2

Special Lecture

SL002

International myopia conferences 1964–2004: favourite myopia theories over time

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Purpose: The First International Conference on Myopia organised by the Myopia Research Foundation (MRF; Sylvia Rachlin, till 1994) took place in New York in 1964 and printed reports of lectures were distributed to interested doctors all over the world. In 1978 the Second International Conference was organised by Tikasi Sato in Yokohama, Japan, prior to the International Congress of Ophthalmology in Kyoto, and the Third Conference took place in Copenhagen in 1980. The latter with published proceedings.

Methods: MRF did not back up these meetings, but organised the Second MRF Conference in San Francisco in 1982 in connection with the International Congress of Ophthalmology. With a similar association the Third Myopia Conference was organised by MRF in Rome 1986, the Fourth in Singapore 1990 and the Fifth in Toronto 1994. Proceedings from these meetings were not ISBN published. At subsequent myopia conferences the numbering was continued and biennial conferences held though without any sponsoring foundation or factual myopia society. In 1996 the meeting took place in Hakone, Japan (Proceedings: Myopia Update) in 1998 in Taipei (Proceedings: Myopia Update II), in 2000 in Boston (Proceedings: Myopia 2000), in 2002 in Hong Kong and Guangzhou and in 2004 in Cambridge, UK. From the last two meetings only abstracts of presentations have been published.

Results: At the end of each meeting, the structure of the assembly has been discussed and the next meeting place decided upon.

Conclusion: Over the 40 years a number of new topics were added to the classical ones like biometry (ultrasound) in 1978 and 1980 and experimental myopia as a main theme at the same conferences and at later meetings. Refractive surgery and scleral reinforcement were included in the eighties.

Plenary Lecture

PL004

The latest findings from COMET and insight into future directions for myopia interventions

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Purpose: The high prevalence of myopia, especially in Asia, and its prominence as a public health problem emphasise the importance of finding effective treatments to slow progression and limit the final amount of myopia. Recent clinical trials have used both optical and pharmacological treatments. A randomised clinical trial of spectacle lenses, the Correction of Myopia Evaluation Trial (COMET), measured refractive error and axial length annually in 469 ethnically diverse 6–11 year-old children with moderate myopia.

Methods: Children were randomly assigned to wear either progressive addition lenses (PALs) with a +2.0 addition, or single-vision lenses (SVLs). Retention of children in COMET after 3 years was outstanding (98.5%).

Results: The main result was a statistically significant treatment benefit of PALs of 0.20 D ($p = 0.004$), which was observed at the end of the first year and sustained at the same level over the next 2 years. Progression of myopia was highly correlated with increase in axial length ($r = 0.86$ for PAL and 0.89 for SVL). Additional analyses of COMET data suggest that certain subsets of myopic children might benefit more than others from wearing PALs, in particular those with reduced accommodative responses in combination with near esophoria (adjusted treatment benefit of 0.64 D) or lower baseline myopia (0.48 D). A new study, COMET2, is enrolling children with these characteristics. The most recent COMET finding is that treatment with PALs only benefited children with 2 myopic parents (3-year treatment effect = 0.45 D, $p = 0.03$).

Conclusion: Issues that must be addressed in order to develop successful, long-term treatments for myopia include the following: (1) identifying which children might benefit from a particular treatment (lenses, drugs), (2) overcoming the maximum one year benefit of most current treatments, (3) sustaining a treatment effect over time, and (4) determining when to institute a treatment and for how long to continue it.

Symposium Papers

S015

Ocular components in emmetropic children as a function of ethnicity

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Purpose: To investigate eye size as a function of ethnicity in emmetropic, school-aged children.

Methods: Children in American primary school grades 1–8 were recruited and examined at five clinical sites (Eutaw, Alabama; Houston, Texas; Irvine, California; Orinda, California; and Tucson, Arizona). Information from each child's first visit (1997–98 or after) was used for this report. Children with cycloplegic autorefraction results between –0.25 D and +1.00 D in both principal meridians were considered emmetropic and were included in this data set. Five ethnic groups were represented in this sample: African Americans (n = 312), Asians (n = 162), Hispanics (n = 264), Native Americans (n = 200), and Whites (n = 358). Refractive error, corneal curvature, crystalline lens parameters, and axial length were measured using cycloplegic autorefraction, autokeratometry, videophakometry, and A-scan ultrasonography.

Results: Corneal curvature in Native Americans was significantly flatter compared to all other ethnic groups ($p < 0.001$).

Conclusion: Emmetropic, Hispanic children have eyes that are longer and corneas that are flatter in the horizontal meridian compared with White children. Native American emmetropic children have eyes that are longer, corneas that are flatter, and lower lens power compared to African American and White children. The eyes of Asian emmetropes were similar with respect to length, cornea curvature and lens power to both African American and White emmetropic children.

S016

Myopia: prevalence, risk factors and natural history

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Purpose: To examine the associations between refractive error and ocular biometry and risk factors for myopia, in two age cohorts of Australian school children of European Caucasian and East Asian ethnicity.

Methods: The Sydney Myopia Study invited participation from all Year 1 and 7 students enrolled in 51 randomly selected schools, stratified by socio-economic status. Participants underwent a comprehensive eye examination including cycloplegic autorefraction and measurement of ocular biometry using the IOLMaster (Zeiss). Families completed detailed questionnaires on near work and outdoor activities outside school hours. Myopia was defined as spherical equivalent ≤ −0.5 D in the right eye.

Results: In the 1765 (participation 78.9%) Year 1 students (mean age 6.7 years) the prevalence of myopia was 1.5% (95% CI 1.0–2.3) and in the 2353 (participation 75.3%) Year 7 students (mean age 12.7 years) the prevalence was 12.8% (95% CI 11.2–14.2). The Year 7 students who engaged in the lowest tertile of hours spent in outdoor activity and highest tertile of near-work had an odds ratio of 2.64 for myopia compared to those children doing the lowest tertile of outdoor activity and highest tertile of near-work.

Conclusion: The prevalence of myopia in Australian school children is low by international standards. There was a significant association between high levels of outdoor activity and a more hyperopic refractive error.

S017

A cohort study of the risk factors for incident myopia in Singapore children

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Purpose: We aimed to determine the risk factors for incident myopia in a school-based cohort study in Singapore children.

Methods: A 3-year prospective cohort study was conducted in Singapore school children aged 7–9 years in 3 schools at entry. Chinese children without myopia at baseline (n = 994) were included in the analysis. The main outcome was incident myopia, defined as spherical equivalent (SE) at least −0.75 Diopters (D) based on cycloplegic autorefraction. Other definitions of incident myopia, at least −0.5 D and at least −1.0 D, were also assessed.

Results: After controlling for school, age, gender, income, reading in books per week and intelligence quotient (IQ) test scores, the relative risk (RR) of incident myopia defined as −0.75 D was 1.55 [95% confidence interval (CI) 1.18–2.04] for

two versus no myopic parents. The multivariate RR of myopia for IQ in the third versus first tertile was 1.50 (95% CI 1.19–1.89). However, the RR of incident myopia was 1.01 (95% CI 0.97–1.05) for every unit increase in books read per week. Similar results were obtained with definitions of −0.5 D and −1.0 D for incident myopia.

Conclusion: These data provide new prospective evidence of essential links between parental myopia, IQ scores and subsequent myopia development. However, reading in books per week was not associated with incident myopia.

S018

Why does close work cause myopia? - a hypothesis

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Purpose: Close work has been implicated in the aetiology of human myopia for at least 100 years but as yet no satisfactory explanation for the mechanisms involved has been advanced. There are many reasons why accommodation that was the earliest aetiological mechanism invoked is not the cause of myopia.

Methods: Both genetic predisposition and the amount of close work appear to be involved in the aetiology of myopia that currently is epidemic in urban Asia. An inbred colony of pigs we have been studying provides an example of a genetically driven myopia with no apparent environmental input. Conversely visual deprivation in early post-natal life induces a myopia that appears to be driven by environmental factors. Animal experiments have shown that a totally blurred image from early life can cause myopia in a wide variety of species. It has therefore been assumed that a sharp retinal image is necessary for emmetropisation.

Results: In everyday life the retina simultaneously receives both in-focus and out of focus images the latter from in front of and from behind the plane of focus for any specific degree of accommodation. As a hypothesis it is suggested that a totally sharp retinal image may be as abnormal as a totally blurred image and may be equally capable of inducing myopia. Additionally during reading most of the retinal input from distant objects is cut off. Light from objects behind the plane of focus would be focused pre-retinally and act as an inhibitor of myopia (in the same way that plus lenses induce hypermetropia). Lack of this input during reading is a second factor that might drive the eye towards axial extension.

Conclusion: The features of what constitutes a normal retinal image are investigated with particular regard to contrast, spatial frequency, edge definition, chromaticity and size differences at different distances from the plane of focus in relation to a possible role for these parameters in the aetiology of myopia. An explanation for the ability of the eye to differentiate between myopic and hypermetropic blur and adjust its growth pattern accordingly is suggested.

S019

Breastfeeding and myopia: a case for developmental plasticity?

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Purpose: The high prevalence of myopia among urban Asian children suggests that early lifestyle factors may influence myopia. While many environmental factors have been studied, nutrition has not been carefully considered. Breastfeeding is the main variable in early nutrition and we studied its association with myopia in school children.

Methods: We performed cycloplegic autorefraction in school children to diagnose myopia after a prior parental-administered questionnaire. Among parameters documented, we asked parents if their child had ever been breastfed and for what duration, and to describe their breastfeeding practice.

Results: A total of 82.9% of the children (405 boys, 392 girls, aged 10–12 years) in a school participated. The prevalence rate of myopia was 65.4%. 52.4% were breastfed (8.5% exclusively, 7.8% mostly, 36.1% partly). 37.4% were breastfed for 3 months or less and 15.0% were breastfed longer. Children who were breastfed had lower myopia rates (62.0%) than children who were not breastfed (69.1%) ($p = 0.04$). A history of being breastfed was significantly protective against myopia (OR 0.73, 95% CI 0.54–0.98). After controlling for child's age, sex, race, birth weight, height, books read per week, IQ scores, mother's education, parental myopia, maternal age at delivery, and household income, the adjusted odds ratio of myopia was 0.58 (95% CI 0.39–0.84). Breastfed children (−1.6 D) were less myopic than that of non-breastfed children (−2.1 D) ($p = 0.001$).

*Conclusion:*Breastfeeding was an independent protective factor against myopia after controlling for known risk factors. The biologic mechanism for myopia protection may involve nutritional factors in breast milk such as docosahexaenoic acid and carotenoids that improve visual development in infants leading to more ordered eye growth. Breastfeeding has previously been associated with improved stereoacuity in young UK children. Animal studies have demonstrated the profound effects of early nutrition on development. If a protective association is confirmed in further human studies, breastfeeding may be a modifiable early lifestyle factor that can be considered for myopia prevention.

S020

Myopia and peripapillary retinal nerve fiber layer thickness

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Purpose: It is often difficult to assess for glaucoma in myopic eyes. The aim of this study was to determine the relationship between peripapillary retinal nerve fiber layer (RNFL) thickness and myopia using optical coherence tomography (OCT).
Methods: This was a prospective observational case series of 132 young males with myopia (from −0.50 to −14.25 diopters). Optical coherence tomography (OCT−1, Version 4.1; Zeiss-Humphrey Systems, Dublin, CA) was performed by a single operator using circular scans concentric with the optic disc with scan diameters of 3.40 mm, 4.50 mm and 1.75x of vertical disc diameter (VDD). For each scan diameter, mean peripapillary RNFL thickness was calculated.
Results: Mean peripapillary RNFL thickness did not correlate with spherical equivalent for the 3.40 mm ($r = -0.11$, $p = 0.22$), 4.50 mm ($r = -0.103$, $p = 0.24$) or 1.75 x VDD ($r = -0.08, p = 0.36$) OCT scan diameters. Mean peripapillary RNFL thickness also did not correlate with axial length for the 3.40 mm ($r = -0.04, p = 0.62$), 4.50 mm ($r = 0.03, p = 0.75$) or 1.75x VDD ($r = -0.02$, $p = 0.78$) scan diameters.
Conclusions: Peripapillary RNFL thickness did not vary with myopia for any OCT scan diameter investigated. This suggests that RNFL thickness measurements may be a useful parameter to assess and monitor glaucoma damage in myopic subjects.

S021

The prediction of visual acuity in pathologic myopia

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Purpose: To investigate the relationship between fundus changes in the posterior pole and prognostic best-corrected visual acuity (BCVA) in pathologic myopia.
Methods: Pathologic myopic patients were examined as follows: (1) Age, BCVA, axial length and posterior fundus changes ($n = 955$). (2) Age, sex, axial length, corneal curvature, visual field and posterior fundus changes ($n = 265$). (3) Besides the above factors, choroidal neovascularisation (CNV) size and onset, and size of hemorrhage around the CNV ($n = 54$) for longer than 5 years.
Results: (1) From the multiple regression analysis of the factors that influence the present visual acuity, a model equation was determined. The most important factor was CNV for present visual acuity. (2) Each factor was investigated with multivariate analysis by quantification II. From the partial correlation coefficient of contributing factors, CNV had excellent correlation with visual acuity. (3) From the multiple regression equation to predict visual acuity, visual acuity at 5 years after CNV onset was significantly associated with patient age, CNV size, and initial BCVA ($p < 0.001$).
Conclusion: CNV is the most important factor on the prognosis of BCVA. This result is important for managing patients of pathologic myopia, for example active recommendation of photodynamic therapy (PDT), injection of anti vascular endothelial growth factor (VEGF), or surgical treatment of myopic CNV.

S022

The risk factors involving in developing myopic maculopathy

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Purpose: To determine the possible risk factors involving in developing of myopic maculopathy.
Methods: Totally, 1245 excessive high myopic (≤ −10.0 D) patients were selected, 832 with myopic maculopathy (at least lacquer crack was found) and 413 without maculopathy. The gender, age, family history, refractive status, axial length, optic nerve crescent were analysed to find out the possible risk factors involved in developing of myopic maculopathy.
Results: The incidence of myopic maculopathy was increased with aging. Female has higher myopic maculopathy (24.3%) than male (14.9%). The severity of macular grading was significantly increased with the myopic refractive status, axial length, and aging. For those cases with early myopic maculopathy (M3), the mean refractive status was −14.0 D, axial length was 29.4 mm, and age was 45 years old. In multivariable models, in persons in excessive myopia group (≤ –10.0 D) to develop early myopic maculopathy, the risk for age increasing every one year old was highly significant (odds ratio [OR] 1.07, 95% confidence interval [CI], 1.05–1.09). The risk for axial length increasing every one mm was also highly significant (OR, 1.70, 95%CI, 1.43–2.01). Besides, the risk for the size grading of crescent was significant (OR, 1.58, 95%CI, 1.17–2.14). The risk for the temporal scleral crescent was highly significant (OR, 17.0, 95%CI, 9.32–31.17).
Conclusion: Refractive status, aging, axial length, the size of crescent, and temporal scleral crescent of optic nerve are the risk factors in the development of myopic maculopathy.

S023

Optical inhibition of juvenile myopia progression

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Purpose: Monocular under-correction (monovision) reduces childhood myopia progression in the under-corrected eye only (Phillips, BJO 2005; 89(9): 1196). The present study considers whether myopic defocus could be used to slow myopia progression bilaterally either by (1) regularly alternating the

under-correction between eyes or (2) wearing dual-focus contact lenses, which correct refractive error and simultaneously cause myopic retinal defocus.

Methods: (1) Accommodation was measured (Shin-Nippon SRW-5000 autorefractor) in pre-presbyopic subjects wearing monovision CLs (+2.00 D or +4.00 D adds) when reading at 25 cm, 50 cm and 6 m with either the dominant or the non-dominant eye corrected for near. (2) A dual-focus contact lens was designed with a central zone which corrects distance vision and peripheral zones which simultaneously impose 2.00 D of myopic retinal defocus. The performance of the lens in 11–14 years old children with myopia (−1.50–4.00 D) is being assessed in the registered (actr.org.au) clinical trial, DIMENZ (Dual-focus Inhibition of Myopia Evaluation in New Zealand).

Results: (1) Monovision subjects (n = 12) accommodated to read with the distance-corrected eye under all conditions: lag of accommodation was not significantly different whether the dominant or non-dominant eye was corrected for near. (2) All children enrolled in the DIMENZ trial (12 to date) wear the lenses full-time and have acuities of 6/6+. When monocularly reading a target at 33 cm through dual-focus lenses they simultaneously report a clear image of a target placed at 20 cm but a blurred image of a target at 1 m.

Conclusion: Monovision worn by pre-presbyopes can induce myopic retinal defocus in either the dominant or non-dominant eye. Dual-focus contact lenses correct refractive error and simultaneously induce myopic retinal defocus. These results suggest that either alternately under-correcting one eye then the other (e.g. on alternate days) or wearing dual-focus contact lenses could slow myopia progression bilaterally while also providing 6/6 distance vision.

S024

Can imposed myopic defocus control the progression of myopia in children?

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Purpose: To determine if imposed myopic defocus can control the progression of myopia in a clinical practice setting.

Methods: The study was approved by the ANU Human Ethnics Committee. Children (age range 5–15) with progressing myopia were recruited from an ophthalmic practice. Informed consent was obtained from parents and participants, who removed their corrections and wore +3D glasses for 30 min day^{-1} for two years. Subjective refractions and A-scan axial lengths were measured every 4 months. At the first and last examinations, cycloplegic retinoscopy (1% cyclopentolate) was also carried out.

Results: The main outcome was subjective refraction. Of the 20 participants with complete sets of data, 6 (30%) showed essentially no progression.

Conclusion: The results of this study are promising, but the limitations are obvious. A Randomised Clinical Trial including cycloplegic refraction and IOLMaster axial length measurements is now in progress in collaboration with the Singapore Eye Research Institute. The potential for the use of imposed myopic defocus to control the progression of myopia is confirmed by the results from a recent monovision trial, in which bursts of increased myopic defocus apparently inhibited axial elongation in the under-corrected eye (Phillips, Br J Ophthalmol 2005; 89:1176–7).

S025

Effect of atropine on astigmatism

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Purpose: The aim of this study is to determine the effect of Atropine on astigmatism.

Methods: From the Atropine Treatment Of Myopia (ATOM1) study, it was possible to compare differences in astigmatic change between atropine treated eyes, and non-atropine vehicle (control) eyes. The inclusion criteria, however, meant that all patients had ≤ 1.5 D astigmatism at baseline. The effect of astigmatic axis ('with' or 'against' the rule i.e. WTR or ATR respectively), and myopic progression were also assessed.

Results: 192 subjects had atropine treatment in one eye, and 194 had vehicle at baseline. The majority of subjects (94% of atropine, 96% of vehicle) had WTR astigmatism at baseline. Two years later, the majority of eyes retained their 'with' or 'against' the rule status (92%). The mean change in astigmatism was –0.29 ± 0.46 D in atropine eyes, and –0.32 ± 0.42 D in vehicle eyes at 2 years. There was a small but significant increase in astigmatism in both groups over the 3 years ($p < 0.0001$). There was, however, no significant difference in astigmatic change between atropine and vehicle eyes ($p = 0.6619$). There is less deterioration in cylinder (D) at 2 years in the ATR compared to WTR after adjusting for treatment received ($p < 0.001$). Myopia progression was naturally significantly less in those subjects on atropine. However, there was no significant difference in myopic progression in those eyes with WTR vs ATR astigmatism ($p = 0.7649$).

Conclusion: In eyes with baseline astigmatism ≤ 1.5 D, atropine treatment over a 2 year period does not appear to significantly influence the amount of astigmatism or its axis.

Note: No comparison between insignificant and significant astigmatism was performed due to the small number subjects in the significant astigmatism group (n = 2 only).

S026

Methodologies for interventional myopia studies

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Myopia studies are notoriously difficult to carry out. Past studies on intervention in myopia progression have given conflicting results. Beside inaccurate and inadequate measurements, the most important cause for this is the very variable nature of myopia, which makes it difficult to achieve baseline comparability between the control and the study group. Although there were inclusion criteria in these studies, for age, sex race, degree of myopia and stigmatism, the most important variate - the rate of myopia progression- was not included. Randomisation can achieve baseline comparability of the myopia progression rate, provided the sample sizes are large enough. Unfortunately past studies have been limited to 100–200 children only. This is why studies on twins are more reliable than random groups because the myopia progression rates are more likely to be the same in a pair of twins. Studies on the same subject, comparing right and left eye would be even better, but this method is practicable only for some studies only (e.g., we cannot have a spectacle lens for one eye and a contact lens on the fellow eye). There is another method of doing an interventional study on myopia. Because myopia progression is linear in it early stage until the early teenage years, it is impossible to observe what happens to the linear progression upon intervention. In this way, we avoid the problem of trying to compare 'apples with apples'. In fact, we are using the 'same apple'.

S027

Establishing an optimal dose of atropine for slowing progression of childhood myopia

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Pharmacological treatment is to date the only viable method of slowing progression of childhood myopia of which atropine is the strongest candidate. The Atropine in the Treatment of Myopia (ATOM) Study demonstrated that 1% atropine was extremely effective in slowing myopia progression and axial elongation, but had undesirable functional side effects such as pupillary dilatation and cycloplegia that resulted in glare and blurred near vision, respectively. The ATOM 2 Study is designed to establish an optimal dose of atopine eye drop for the prevention of rapid myopia progression by evaluating and comparing the efficacy, safety and functional impact of binocular treatment with 0.5%, 0.1% and 0.01% atropine eye drops. The study design will be described. The ATOM 2 Study is a double-masked single-centre clinical trial wherein 400 children aged 6–12 years, with myopia of −2.00 D or worse in each eye, and from whom assent and parental/guardian consent have been obtained, will be randomised to receive 0.5%, 0.1% or 0.01% atropine once nightly in both eyes. Participants will be assigned to treatment in the ratio of 2:2:1, respectively. Each child will receive treatment for a period of 2 years during which they will be reviewed every 4 months. The primary outcome is progression of myopia, defined as the magnitude of change relative to baseline in spherical equivalent refraction in each eye as determined by cycloplegic autorefraction. The secondary outcome is change in axial length, as measured by non-contact partial coherence interferometry. The safety and functional outcomes include a parent and child-administered modified VF-14 questionnaire, induced cycloplegia assessed by near acuity and amplitude of accommodation tests, pupil reactivity and diameter assessment, and retinal function assessment by electroretinography.

S028

The contact lens and myopia progression (CLAMP) study

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Purpose: To compare the effects of gas permeable contact lenses and soft contact lenses on myopia progression in children.
Methods: Following a run-in period to include only 8- to 11-year-old myopic children who could adapt to gas permeable contact lens wear, 116 subjects were randomly assigned to wear gas permeable contact lenses or soft contact lenses. Cycloplegic autorefraction, keratometry, and a-scan ultrasound axial length measurements were measured annually for three years. Intent-to-treat analyses were performed using differences in the three-year change in spherical equivalent cycloplegic autorefraction between the two treatment groups.
Results: Gas permeable contact lens wearers progressed 1.56 ± 0.95 D and soft contact lens wearers progressed 2.19 ± 0.89 D (ANCOVA, $p < 0.001$). The eyes grew 0.81 ± 0.51 mm for the gas permeable contact lens wearers and 0.76 ± 0.44 mm for the soft contact lens wearers (ANCOVA, $p = 0.57$). The steep corneal meridian steepened 0.62 ± 0.64 D for the gas permeable contact lens wearers and 0.88 ± 0.57 D for the soft contact lens wearers.
Conclusion: Although the refractive error progressed significantly faster for the soft contact lens wearers, much of the treatment effect was due to differences in corneal curvature changes but not differences in axial growth. The treatment effect is small and likely to be due to reversible corneal changes. Gas permeable contact lens wear should not be prescribed for children solely to slow myopia progression.

Free Papers

F025

Impact of parental myopia and near-work on childhood refraction: a comparison of two ethnic groups in the Sydney myopia study

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Purpose: To compare the impact of parental myopia and near-work on childhood refraction within two ethnic groups in a population-based sample of 12-year old Australian children.

Methods: The Sydney Myopia Study examined 2353 Year 7 students (75.3% response) from a random cluster-sample of 21 secondary schools across Sydney. Refraction was assessed by cycloplegic autorefraction and data on near work were sought in questionnaires.

Results: Mean age of participants was 12.7 years; 49.4% female. The prevalence of myopia among children of Caucasian (n = 1407) ethnicity with one (6.0%; 95% confidence interval, CI 2.9–9.1) or two (17.2%; CI 6.5–27.9) myopic parents was significantly higher than among children with no myopic (3.0%; CI 2.0–3.9) parents. Similarly, myopia prevalence was higher among children of East Asian ethnicity (n = 352) with one (48.6%, CI 39.3–57.8) or two (77.3%, CI 69.8–84.8) than no myopic (28.2%, CI 14.9–41.5) parents. Mean spherical equivalent, SE, for children of Caucasian ethnicity with none, one or two myopic parents was 1.0 diopters (D), 0.7 D and 0.3 D, respectively. For children of East Asian ethnicity, corresponding values were (0.1 D, (0.9 D and (2.3 D. Overall trends in mean SE with tertiles of near-work hours were not significant for children with (p_{trend} = 0.7) and without myopic (p_{trend} = 0.1) parents, adjusting for confounders. Among children of Caucasian ethnicity, mean SE was significantly more myopic in the highest compared to lower tertiles of near-work ($p < 0.05$), but the overall trends across tertiles were not significant (all $p_{trend} > 0.05$). No significant trends in mean SE with near-work tertiles were found for East Asian ethnic groups. In each near-work tertile, mean SE was substantially lower for children with than without parental myopia, adjusting for confounders.

Conclusion: Parental myopia impacted significantly on the prevalence of childhood myopia and mean SE that was clearly evident in both Caucasian and East Asian ethnic groups, after adjusting for near-work and other confounders.

F026

Health-related quality of life in Singapore myopic adolescents: a preliminary report

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Purpose: To evaluate the health-related quality of life (HRQoL) reported by adolescents with myopia and their parents in Singapore.

Methods: A cross-sectional study was conducted in 2005 and 2006 within the Singapore Cohort study of the Risk factors for Myopia (SCORM) which is a longitudinal cohort study that commenced in 1999. Cycloplegic autorefraction measures were made using the Canon RK-5 autokeratorefractometer and the measurements were analysed as spherical equivalent. Myopia was defined as a negative refractive error of at least (−0.5 D. Adolescents were classified into myopes and non-myopes based on the worst eye. Parents or proxy and their child completed the PedsQLTM 4.0 generic core scales (parent-proxy and child-self reports for 13–18 years) independently. Summary scores for total, physical and psychosocial health of myopes and non-myopes were compared.

Results: The data collection is still on going but the preliminary results of 82 adolescents aged 12–14 years are reported here. Thirty-seven adolescents (45%) were classified as myopes and majority of myopes were females (70% vs 30%, p = 0.0034). The mean (SD) total, physical and psychosocial health scores reported by myopes were 84.9 (10.3), 91.5 (7.8) and 81.4 (13.1). Although lower scores in myopes (indicating worse HRQoL) for all but physical scores, these were not statistically significant differences. The differences in total scores and associated 95% Confidence Intervals were 0.4 (95% CI: −3.9 to 4.8), physical −0.8 (−4.7 to 3.2) and psychosocial health 1.1(−4.2 to 6.4). Nonetheless, parents of myopes reported lower scores for all scales. Parents also reported slightly lower scores than children but these differences were insignificant between myopes and non-myopes. The results remain unchanged after controlling for the child's gender.

Conclusion: The HRQoL reported by the adolescents with myopia and their parents in Singapore were slightly but not significantly lower. We await further data from all 1,500 adolescents from the 2006 eye-screening visit in SCORM.

F027

Risk factors for the development of myopia in Spain

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Purpose: To evaluate the risk factors for the development of myopia in university students in Spain.

Methods: A cross-sectional study was conducted in university students aged 18–29 years ($n = 270$) in Spain. Cycloplegic autorefraction was measured using a TOPCON 8100 autorefractometer. The participants were asked to fill out a questionnaire about different risk factors for myopia: family history of refractive errors, hours of study, hours of sports activity, and sociocultural status of the family.

Results: Students who spend more daily hours of study ($p < 0.001$ Spearman rho $= -0.22$) and less hours of outdoor sports activity (χ^2 $p = 0.03$) have more myopia. Student with myopic parents or siblings have more myopia. Myopia occurred in three-fourths (76%) of students with two myopic parents, half (48%) of students with one myopia parent, and one-third (33%) of students with neither parent myopic (χ^2 $p = 0.002$). Half (49%) of the myopic but only a third (30%) of non-myopic students had at least one myopic sibling (χ^2 $p = 0.003$). No relationship was found between student myopia and the level of their parents' education or occupation, whereas a significant correlation between increased parental myopia and educational (χ^2 $p = 0.004$) and occupational level (χ^2 $p = 0.009$).

Conclusion: Both environmental and genetic factors are related to the development of myopia in university students. However, since parents and their children are exposed to similar environmental influences it is difficult to separate these factors.

F028

What is the real prevalence of Myopia?

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Purpose: This study was carried out to know the differences in the prevalence of refractive error obtained by three different methods of measurement using the spherical equivalent (SER) to characterise the refractive error with the cut of point of ± 0.25 D and ± 0.50 D. We also investigate the influence of using cycloplegic refraction on ametropia prevalence.

Methods: A population sample of 199 young adults were randomly selected and examined. The exam protocol consists in the evaluation of the refractive error by the retinoscopy, autorefraction and subjective distance refractive method with and without cycloplegia. The results obtained were converted into SER; myopia cut-off points were defined for SER ≤ -0.50 D, and for SER ≤ -0.25 D. The prevalence of myopia for different cut-off points and measurement methods were compared.

Results: Considering the cut-off point of -0.50 D for the retinoscopy the variation without and with cycloplegia is 6% (26.6–20.6%); for the subjective refraction the variation is only 2% (22.6–20.6%). Conversely, using or not cycloplegia with auto-refraction induces a variation in myopia prevalence of 27.1% (21.6% and 48.7%, respectively). Considering the cut-off point of (0.25 D for the retinoscopy the variation without and with cycloplegic is 9.6% (35.2–25.6%); for the subjective refraction the variation is only 4.6% (30.2–25.6%) and for the autorefraction the variation is 38.2% (62.3–24.1%).

Conclusion: The prevalence of myopia varied from 20.6% when SER is obtained with retinoscopy or subjective distance refractive with cicloplegic (cut-off -0.50 D) to 62.3% when as obtained with auto-refraction without cycloplegia (cut-off -0.25). The present study shows that world-wide standardisation on methods to define myopia prevalence is mandatory in order to get a more realistic view of trans-regional comparisons in myopia prevalence. This will help to obtain more accurate information on the impact of myopia among different ethnic groups.

F029

Biometric correlates of myopia in white British, Hong Kong Chinese, and Japanese eyes

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Purpose: To examine the correlation between mean spherical equivalent refraction (MSE) and ocular biometric parameters in young adult White British (WB), Hong Kong Chinese (HKC), and Japanese (Jp) university populations.

Methods: A non-contact Partial Coherence Interferometry (PCI) method (IOLMaster, Zeiss) was used to examine ocular dimensions. Refractive error was measured using an infrared, objective, open-view autorefractor (NVisionK 5001, Shin-Nippon). The cohorts consisted of 51 WB adults (mean age 26.52 $\pm$ 4.45 years; range, 20–36 years), 31 HKC adults (mean age 23.26 $\pm$ 2.76 years; range, 19–30 years), and 35 Jp adults (mean age 21.69 $\pm$ 1.53 years; range, 19–27). Measures of axial length, anterior chamber depth, corneal radius of curvature and non-cycloplegic objective ocular refraction were recorded for each eye. There was no significant difference in biometry between eyes so only right eye data is reported.

Results: MSE was (0.78 $\pm$ 2.14 D (range, -6.05 to $+6.37$ D) for WB, -3.42 $\pm$ 2.98D (range, -9.56 to $+3.87$ D) for HKC, and -2.50 $\pm$ 2.33 D (range, -7.13 to $+$ 0.25 D) for Jp eyes.

Axial length was negatively correlated with MSE in all populations ($p < 0.001$), but the relationship was stronger in the WB ($r^2 = 0.62$) than in the HKC ($r^2 = 0.39$) and Jp ($r^2 = 0.33$). Anterior chamber depth was negatively correlated with MSE, but only in WB and Jp ($p < 0.05$). Corneal curvature was not related to MSE in any of the populations, but was positively correlated with axial length in Jp ($p < 0.05$). The axial length to corneal curvature ratio was negatively correlated to MSE, but more strongly in the HKC ($r^2 = -0.47$, $p = 0.002$) and Jp ($r^2 = -0.59$, $p < 0.001$) than WB ($r^2 = 0.19$, $p = 0.002$).

Conclusion: Axial length alone and its ratio with corneal curvature are the main biometric correlates of refractive error in all groups, although the former is stronger and the latter weaker for WB compared to Asian eyes.

F030

The children's attitudes about kids in eyeglasses (CAKE) study

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Purpose: To determine whether spectacle wear has an affect on how children feel about other children wearing glasses.

Methods: Subjects compared a series of 24 picture pairs and answered which child he or she would rather play with, looks better at playing sports, appears smarter, appears nicer, looks more shy, and looks more honest. The children in each pair of pictures differed by gender, ethnicity and spectacle wear. Logistic regression was performed to determine the chance of picking the spectacle wearer and to determine the chance of picking a child who had similar characteristics as the child doing the picking (same gender and spectacle-wearing status).

Results: Eighty subjects between the ages of 6 and 10 years participated. The average (±SD) age of the subjects was 8.3 ± 1.3 years, 42 (53%) were female, 51 (64%) were white, 21 (26%) were black, and 30 (38%) wore glasses. The probability of picking the spectacle wearer was significantly greater than chance when asked which child looks smarter (0.66, CI = 0.62–0.69) and which child looks more honest (0.57, CI = 0.60). Subjects who wore spectacles picked the spectacle wearer as looking smarter 69% of the time (CI = 62–75%) and subject who didn't wear glasses picked the non-spectacle wearer as looking smarter 36% of the time (CI = 32–41%). Males picked boys as looking better at playing sports 82% of the time (CI = 76–86%) and girls picked girls 30% of the time (CI = 23–37%).

Conclusion: The large sample size provides statistically significant results that may not be clinically meaningful. Including only results in which subjects choose one category 60% of the time or more, glasses only make children appear smarter. These results are consistent whether the subject is a spectacle wearer or not. Spectacle wear did not affect who children picked as looking more athletic. Boys were picked as the child who looks better at playing sports significantly more often than by chance, regardless of whether the subject picking was a boy or girl. In summary, glasses make children appear smarter to other children and boys appear more athletic than girls to other children.

F032

Poor metabolic control in diabetic patients; a risk factor of myopisation

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Purpose: As a consequence of an increasing prevalence of myopia in parts of the world that has adopted western dietary patterns it has been hypothesised that hyperglycaemia and hyperinsulinaemia induce myopia. The purpose of this study was to evaluate the relation between glycosylated haemoglobin (HbA1c), insulin dosage and myopisation in diabetic patients.

Methods: A total of 383 type 1 diabetic patients aged 16–26 years [mean age 22.0 (SD 2.9)] attending the eye clinic at Steno Diabetes Centre, Copenhagen, in 1995–97, were included in a retrospective cohort study. The following data were collected from the medical records from baseline to 2005: age at diabetes onset, age at baseline, sex, weight, HbA1c, insulin dosage, refractive error (automated refraction in cycloplegia), visual acuity and diabetes related complications.

Results: The prevalence of myopia (≤−0.5 D, spherical equivalent) was 53.3% [95% CI (confidence interval) ± 5.29] at baseline and 65.6% (95% CI ± 5.88) at the last eye examination [mean follow-up 7.1 years (SD 2.2)]. In a logistic regression analysis, duration of diabetes [OR (Odds ratio) 0.918 (95% CI 0.873; 0.966), $p = 0.001$], refraction at baseline [OR 0.858 (95% CI 0.742; 0.992), $p = 0.038$] and HbA1c [OR 1.270 (95% CI 1.058; 1.526), $p = 0.011$] were related to myopisation, whereas insulin dosage was not [OR 1.833 (95% CI 0.595; 5.647), $p = 0.291$].

Conclusion: In agreement with previous refraction studies in diabetic patients, myopia was more frequent in the study population than in non-diabetics. Shorter duration of diabetes, more negative refractive values and higher HbA1c at baseline were related to myopisation, whereas insulin dosage was not.

F033

Respiratory system directly influences visual system: Scanlan's general theory of myopia

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Purpose: To test the hypothesis that the respiratory system applies air pressure to the rear of the eyeballs influencing the

shape of the eyeballs and hence influencing clarity of vision at different distances (refractive state), such that lower than normal pressure in the respiratory system gives rise to myopia.

Methods: Comparison of the results of previously published studies to the predictions of the hypothesis being tested.

Results: Previously observed correlations between the incidence of myopia and factors affecting the respiratory system, including asthma, pregnancy and stress, support the hypothesis being tested. Other observations including those in relation to changes to the length of the eyeball during accommodation and over various time scales, the paranasal sinuses, the photic sneeze response and extraocular muscles also support the hypothesis being tested.

Conclusion: The respiratory system directly influences the visual system. The simple hypothesis put forward in this paper explains some important but previously unknown or misunderstood aspects of the visual system (including the cause of myopia, the mechanism of accommodation and the role of blinking) and aspects of the respiratory system (including the role of the paranasal sinuses and implications of breathing pattern).

F034

The predictors of refractive changes in young adults

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Purpose: The purpose of this study was to identify the predictors of refractive changes in young adults.

Methods: One hundred and eighteen university students with a mean age (mean ± SD) of 20.6 ± 2.3 years were enrolled in a 3-year longitudinal study. Measurements included subjective refraction with cycloplegic, A-scan ultrasonography, corneal topography, binocular vision and accommodative parameters at two different examinations over the period of 2002–2005. A questionnaire about the time spent in nearwork activities was also performed. Binary logistic regression was used to investigate the association with continuous or categorical independent variables. The refractive alterations were considered when a myopic shift equal or above −0.50 D was observed (no hyperopic shift was observed in any subject).

Results: Axial length (AL), base in break point in far vision (BBI) and temporal peripheral corneal radius (TR) were all significant predictive factors for myopic shift in young adults. The goodness-of-fit for the logistic regression model was performed with the Hosmer–Lemeshow method ($p = 0.758$) and the final model show a predictive capacity of 84.7%. The best single predictor was the AL (231.7%), followed by the BBI (14.2%). The contribution of the TR was 2.6%. The accommodation (lag of accommodation, positive and negative relative accommodation), refractive error, and time spent in nearwork activities did not show any influence in the logistic regression model. The other biometric parameters (anterior chamber depth, lens thickness, vitreous chamber depth), other peripheral and central corneal radius, and the other binocular vision parameters (phoria, base in and base out vergences in far and near vision and AC/A) did not show any significant contribution to the model.

Conclusion: Late refractive alterations can be predicted with moderate accuracy using the AL, BBI and TR.

F035

The prevalence of myopia in Australian aboriginal children of the Arnhemland islands

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Purpose: The island communities of Arnhemland continue to live an almost traditional lifestyle fishing for turtle and dugong. The refractive status of Aboriginal school children in three island communities was assessed.

Methods: All children attending school at the communities of Warruwi, Minjilang and Galiwinku were targeted for visual acuity assessment using the Lea Symbol Chart at 3 m plus refraction by non-cycloplegic retinoscopy in a 10 m room, followed by subjective refraction.

Results: Of all 140 students attending school on the days of testing (two thirds of children living in the communities), those with marked timidness and unreliable responses (22 very young children), profound learning difficulties (1), history of ocular pathology (1) or no form consenting to scientific use of results (4) were omitted from the analysis, leaving a total of 112 full blood Aboriginals aged from 5 to 20 years with 87.5% aged 12 years or less in the study. All students achieved 3/3 unaided acuity, 95% having better than this. Mean monocular acuity was 3/2.2 ± 0.33 and binocular acuity 3/1.99 ± 0.28. No myopic refractive errors were demonstrated. Spherical equivalent refractive errors ranged between +1.00 DS and +2.50 DS, with mean +1.51 ± 0.29 DS by retinoscopy. Subjective refraction was approximately 0.7 DS less than by retinoscopy. Only 13.4% of individuals demonstrated astigmatism. Astigmatism ranged from 0.25 to 0.50 DC and was predominantly with-the-rule. There were no gender differences and no age related changes in refraction. Teachers were unaware of any young individuals in the communities wearing spectacles or with vision difficulties.

Conclusions: The children of these island communities live a hunter-gatherer lifestyle. Literacy remains poor throughout the school years and English is a second language for these children. The apparent absence of myopia may be due to the relatively unstressed lifestyle and reduced near demands.

F036

Comparison of monochromatic aberrations in myopic and emmetropic children

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Purpose: To compare aberration profiles between myopic and emmetropic children from the Sydney Myopia Study.

Methods: Cycloplegic refractive error and aberrations were obtained from two samples [sample 1 (S1); mostly 6 years old] and [sample 2 (S2), mostly 12 years old] using a S-H aberrometer. Eyes with astigmatism > 1.00 D & PD < 5 mm were excluded. Myopia was defined as $-0.50 \leq M < -3.00$ D; emmetropia was defined as $+0.50 < M < -0.50$ D. The RMS from 2nd through 6th order was analysed. Refractive groups were compared using Independent samples *t*-test; samples were compared using multivariate test followed by group *t*-tests with significance set at $p < 0.05$.

Results: A total of 166 myopes (29 S1; 137 S2) and 589 emmetropes (140 S1; 449 S2) were analysed. Mean M of myopes was -0.94 ± 0.39 D (S1); -1.42 ± 0.76 D (S2) and emmetropes was 0.18 ± 0.25 D (S1); 0.14 ± 0.26 D (S2). Differences were found for Defocus & Total Aberrations RMS between myopes and emmetropes in both samples ($p < 0.001$). Furthermore, differences were found for Astigmatism, Coma and HO RMS in S2 ($p < 0.05$). Comparison of same refractive error groups from both samples revealed differences in Defocus RMS, and Total RMS ($p < 0.001$) between myopes, and SA RMS, Secondary Astigmatism and Total RMS ($p < 0.05$) for emmetropes.

Conclusion: In children, differences in RMS between myopes and emmetropes eyes exist for low order aberrations at younger age only. An increase in higher orders RMS in S2 in comparison to S1 was more evident in emmetropes than in myopes.

F037

Improving accommodation accuracy and dynamics in young myopes

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Purpose: To test a potential treatment for improving accommodation accuracy and accommodation dynamics in young myopes.

Methods: A double-masked placebo controlled design was used. One hundred and two 14–21 year old myopes were assessed for accommodation accuracy (accommodation stimulus-response function slope and accommodative lag) and distance and near accommodative facility, before and after a three-month treatment period. Static accommodation accuracy was improved by using spherical aberration controlling custom-designed soft contact lenses. Dynamic accommodation speed was improved by accommodative facility training.

Results: Accuracy of the accommodative response to targets at real distances improved significantly in the group receiving the customised spherical aberration contact lenses compared to the group receiving contact lenses which did not affect their spherical aberration. Accommodative facility rates improved significantly in the group receiving accommodative facility training compared to the control group.

Conclusion: Spherical aberration control and accommodative facility training are a suitable treatment for improving accommodation accuracy and dynamics in young myopes. These improvements were sufficient to counteract the abnormalities in accommodation accuracy and dynamics that have been found in progressing myopes. The potential of these treatments as a means to reduce the rate of myopia progression is currently being investigated.

F038

The autonomic profile under the different accommodative conditions between myopes and emmetropes

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Purpose: Non-invasive Fast Fourier Transformations (FFTs) of heart rate variability (HRV) was used to investigate the autonomic profile under static accommodative stimuli condition and dynamic open-loop condition between myopes and emmetropes.

Methods: A total of 80 subjects (18–30 years) participated in the study (26 emmetropes, 27 progressing myopes and 27 Stable myopes). The accommodative response was measured monocularly at 0, 2, 3, 4 and 5 D accommodative demand under static condition. Tonic accommodation (TA) was measured in the darkness. Following a 15-minute near task (3 D) the change in accommodation response back to darkness was measured over a two minute time period under open-loop condition. The accommodative responses were obtained for each accommodative level above with the open-view Shin-Nippon NVision-K 5001 infrared optometer, while simultaneous continuous measurement of HRV was recorded with a piezo-electric finger pulse transducer.

Results: FFTs of HRV shows that increasing the accommodative demand under static condition leads to an increase in parasympathetic control (High frequency, HF) ($F = 3.03$, $p = 0.02$), and a concurrent reduction in sympathetic control (Low frequency, LF) in all subjects ($F = 3.63$, $p = 0.01$).

After near task, parasystemic sympathetic innervation increase in all subjects under dynamic open-loop condition ($F = 7.32$, $p = 0.008$). However, there was no significant difference of HF or LF between refractive groups under either static accommodative condition or dynamic open-loop condition. There were no significant correlation between accommodative response, as well as TA, and autonomic components (HF or LF) respectively.

Conclusion: Both the increase of accommodative demand and near task lead to an increase in parasympathetic innervation. The autonomic profiles in different accommodative conditions can be quantified using FFTs of HRV. But FFTs of HRV cannot detect the difference of autonomic profiles between refractive groups.

F039

Accommodation dysfunction not characteristically different in low myopia

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Purpose: Many hyperopes and emmetropes have accommodation dysfunction but do not progress to myopia. The aim of this study was to assess aspects of accommodation in a clinical population of emmetropes and low myopes with the aim of determining possible etiological factors for myopia.

Methods: Refraction, and aspects of accommodation were measured using a Shin-Nippon NVision-K 5001 free-space auto-refractor. Accommodation posture at near was measured for a target at 40 cm. 'Proximal' accommodation was measured monocularly through an infra-red multiple pin-hole filter for both distance and near targets. The array of multiple pin-holes provided a more complete peripheral visual field. Subjects were drawn from a clinical population presenting to a private optometric practice, age range 9–22 years. The emmetrope group ($\geq +0.50$ D to $+1.25$ D) were followed for at least 6 months and shown to have stable refraction. 'Incipient' low myopes were $\leq +0.25$ to -1.50 D and were spectacle plane corrected during the testing.

Results: Many subjects in each group showed accommodation dysfunction. Near accommodation posture (relative to task demand) was very variable and not significantly different in the low myopes ($+1.56 \pm 0.36$ D) compared to emmetropes ($+1.77 \pm 0.66$ D). Pin-hole proximal accommodation was very variable and not significantly different in the two groups, (myopes $+0.57 \pm 0.72$ D; emmetropes $+0.72 \pm 0.82$).

Conclusion: Objective 'on-axis' 'clinical snap-shot' measures of accommodation function did not distinguish 'incipient' myopes from emmetropes. This finding is consistent with myopia aetiology models involving integrated 'off-axis' peripheral retina image degradation in response to sustained near tasks rather than foveal blur due to transient accommodation dysfunction.

F040

Investigation of near accommodative facility in younger and older myopic children

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Purpose: To study the effect of age on near accommodative facility in younger and older myopic children.

Methods: Fifty-four myopes and 59 emmetropes between age group of 8–18 years without any binocular vision anomalies and any ocular diseases were enrolled for the study. All subjects underwent detailed ocular examination and cycloplegic retinoscopy. Near accommodative facility was measured with ± 2.00 D accommodative flippers with best refractive correction over one minute period. Subjects were divided into two different age groups – group 1: subjects with <12 years of age and group 2: subjects aged 12 years or more. Mean spherical equivalent refractive error in myopes was –2.70 DS (S.D. $\pm$ 1.70 DS) in right eye and –2.86 DS (S.D. $\pm$ 2.14 DS) in left eye. Mean spherical equivalent refractive error in emmetropes was 0.29 DS (S.D. $\pm$ 0.33 DS) in right eye and 0.29 DS (S.D. $\pm$ 0.33 DS) in left eye.

Results: Data was analysed with accommodative facility as dependent variable and age and refractive error as independent variables. There was a significant influence of age on binocular near accommodative facility ($p = 0.02$). Refractive error also showed significant influence on binocular near accommodative facility ($p < 0.0001$) in both groups. There was a significant interaction of age and refractive error together on binocular near accommodative facility ($p = 0.003$).

Conclusion: Our results suggest that young myopic children have significantly lower near accommodative facility than emmetropic children. Older children show no significant difference.

F041

Accommodative status of children enrolled in the DIMENZ trial (dual-focus inhibition of myopia evaluation in New Zealand)

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Purpose: This study investigates the accommodative status of children enrolled in the Dual-focus Inhibition of Myopia Evaluation in New Zealand (DIMENZ) clinical trial. DIMENZ, a prospective randomised controlled trial, evaluates the rate of myopia progression in adolescents wearing dual-focus (DF) contact lenses that provide clear distance vision with simultaneous myopic retinal defocus of 2.00 D. The aim is to measure the accommodative response of participants wearing DF contact lenses and quantify the

amount of myopic retinal defocus present for distance and near targets.

Methods: Children (11–14 years old, $n = 10$) were fitted with a DF contact lens in one eye, randomly assigned to the dominant or non-dominant eye, and a single vision distance (SVD) lens in the fellow eye. After 2–3 weeks of lens wear, accommodative response was measured (Shin-Nippon SRW-5000 Autorefractor) in the fellow eye through a SVD lens and also through a single vision near (SVN) lens (+2.50 D add) that reduced the accommodative demand to zero. Measuring accommodation through the DF contact lens was variable with large standard deviations (up to 0.82 D).

Results: When children changed their gaze from 4 m to 40 cm, accommodation increased by 1.94 ± 0.32 D when wearing the SVD lens and by 1.70 ± 0.37 when wearing the SVN contact lens. There was no significant difference between these two responses ($p = 0.28$).

Conclusion: Children do not use simultaneous vision lenses in the same manner as presbyopes use bifocal contact lenses. In children, accommodative response appears to be driven through the distance portion of the DF contact lens, whether the fellow eye is corrected with a SVD or SVN contact lens. Thus, DF contact lenses cause simultaneous myopic retinal defocus for distance and near targets, providing a potential 'anti-myopiagenic' stimulus for all viewing distances.

F042

Myopia: a magno preference?

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Purpose: To determine whether myopes and emmetropes could be distinguished in the way they process or use magnocellular information.

Methods: Two experiments were conducted. Eleven myopes (–0.75 to –3.00 D) and 13 emmetropes (plano) participated in the first experiment. The subjects were instructed to localise targets in natural scenes. Six different targets were considered. Images were displayed for 100 ms with normal or low-pass filtered spatial-frequency contents. Three levels of blur were investigated. In the second experiment, 20 subjects (10 emmetropes and 10 myopes –0.50 to –3.50 D) had to perform a retain-to-compare task. Four natural scenes were considered. Four different test images were generated for each scene: non-filtered, high-pass filtered, low-pass filtered and hybrid images. Hybrid images were constituted by the low spatial-frequencies (SF) of one scene and the high SF of another scene (Schyns, Oliva, 1994, Psychol. Sc. 195–200). In both experiments visual stimuli were grayscale images.

Results: The results of the first experiment showed that myopes were more efficient than emmetropes and that they better maintained their localisation performances as the level of blur increased. Regarding the second experiment, results showed that when low and high SF were displayed simultaneously in hybrid images, myopes exhibited a strong bias in favour of low SF whereas emmetropes did not show any preference.

Conclusion: The first experiment showed that, when the task involved the dorsal visual stream (the dorsal stream being mainly fed by magnocellular information), myopes performed better than emmetropes. The second experiment highlighted that myopes preferred the low SF of hybrid images, these low SF being conveyed by magnocellular cells. These experiments suggest that myopes exhibit (1) a better efficiency to process magnocellular information than emmetropes and (2) a tendency to favour magnocellular information.

F043

Contrast sensitivity and aberrations in the eyes with super normal vision

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Purpose: To quantify ocular aberrations in eyes with super normal vision, that is natural uncorrected Pelli-Robson contrast sensitivity 1.65 log units, to analyse the correlation of aberrations between the right and left eyes.

Methods: Ocular aberrations were examined across dilated (with 10% phenylephrine) pupil with a diameter 6.0 mm under mesopic conditions in 80 eyes of 40 subjects with 1.65 log units contrast sensitivity (mean age 23.68 ± 2.86) using the Zywave aberrometer. Root mean square (RMS) values of higher order aberrations (HOA), 2nd order, 3rd order, 4th order, and 5th order were analysed. Correlation analysis was performed to assess the association between age, thickness and higher order aberrations and the correlation of aberrations between right and left eyes.

Results: Mean RMS values were 0.38 ± 0.20 mm for total aberrations, 0.20 ± 0.09 mm for higher order, 0.89 ± 0.62 mm for 2nd order, 0.33 ± 0.17 mm for 3rd order, 0.22 ± 0.12 mm for 4th order, 0.72 ± 0.05 mm for 5th order. There was no significant difference in the mean values of HOA, 2nd, 3rd, 4th, and 5th order aberrations between right and left eyes. The Pearson correlation coefficient between right and left eyes for total aberrations was 0.789 ($p < 0.0001$). No significant correlation was found between right and left eyes for 2nd, 3rd, 4th, and 5th order aberrations. No significant correlation was found between each of the aberrations and thickness of the cornea.

Conclusion: The individuals with good contrast sensitivity have an amount of HOA similar in magnitude to those revealed in refractive surgery myopic patients.

F044

Refractive changes associated with oblique viewing in myopes and emmetropes

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Purpose: It has been suggested that during oblique viewing forces applied by structures external to the eyeball, such as the lids and extraocular muscles, may affect eyeball geometry and refraction. We investigated the effect of brief periods of monocular oblique viewing on refractive error in myopes and emmetropes.

Methods: The refractive error and higher order aberrations were measured in 10 myopes and 10 emmetropes with a Hartmann-Shack aberrometer (IRX3, Imagine Eyes, Paris). Each subject's head was positioned such that they either looked straight into the aberrometer with the right eye to observe the internal fixation target, the left eye being occluded, or their head position was rotated to the right or left by approximately 30 degrees so that they had to make an eye rotation of the same angle to see the target. Ten measurements of wavefront aberration (2nd to 10th order Zernike terms) were taken over a period of 3 min at each head position.

Results: Axial refractive error measured in central and nasal and temporal oblique gazes of 30 degrees showed significant differences in spherical equivalent refraction (Repeated measures ANOVA: $p = 0.001$) but not in the astigmatic components J0 and J45 (Repeated measures ANOVA: $p > 0.05$). Refractive group also had a significant effect on change in spherical equivalent refraction with oblique gaze (Repeated measures ANOVA: $p = 0.005$). The differences in refractive error between central and oblique gazes were, however, only of the order of 0.12D and hence clinically of an insignificant magnitude. Monochromatic aberrations showed no significant difference in total RMS error (3rd to 10th order) between central and oblique viewing conditions (Repeated measures ANOVA: $p = 0.405$).

Conclusion: The refractive error in myopes and emmetropes shows a change under oblique viewing conditions. The effect of reading on axial and peripheral refraction will be discussed.

F045

The effect of positive-lens addition and base-in prism on accommodation accuracy and near horizontal phoria in Chinese myopic children

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Purpose: To determine the combination of positive-lens addition and base-in prism power that minimises both near focusing errors and latent horizontal deviations in Chinese myopic children.

Methods: Twenty-nine healthy Chinese myopic children aged 7–13 years were recruited. The children's distance refractive errors were corrected, and measurements of accommodation accuracy and near horizontal phoria were made under closed-loop binocular viewing conditions at 33 cm. The Shin-Nippon open-field auto-refractor (right eye measurement) and Howell-Dwyer near phoria card were utilised. Positive-lens addition powers of 0, +0.75, +1.50, +2.25, +3.00 D and base-in prism powers of 0, 1.5, 3 Δ each eye, giving a total of 15 combinations, were randomly introduced in the form of flippers and accommodation and phoria measures repeated. The accommodation and phoria data were analysed graphically and the lens and prism power that minimised both the accommodation error and phoria determined.

Results: This group of Chinese myopic children (mean age: 10.3 ± 1.9 yr) had an average spherical equivalent refractive error of -2.73 ± 1.31 D, average accommodative error of -0.99 ± 0.73 D (lag) and near phoria of -0.50 ± 4.3 (exophoria). The positive-lens addition decreased the accommodative lag but increased the exophoria as the power increased (e.g. up to -9 ± 4.3 with +3 D). In the graphical analysis of the group data, within the range of lens and prism powers tested, a lens addition of +2.25 D combined with a six base-in prism minimised both the lag and lens induced exophoria in all children (-0.40 ± 0.50 D and -2.6 ± 3.5). This combination decreased the lens induced exophoria by 3.8 compared to that measured with +2.25 D alone (-2.6 ± 3.5 vs -6.4 ± 4.0). A 6 base-in prism totally controlled the exophoria induced by a +1.50 D addition (-0.3 ± 5.0), but the accommodation lag was still considerable (-0.69 ± 0.54 D).

Conclusion: This study suggests that incorporating near base-in prism when prescribing bifocal lenses for myopic children with exophoria could assist in reducing the positive lens induced oculomotor imbalance.

F046

Correlation between accommodative response and myopic progression

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Purpose: To observe the change of accommodative response with myopic progression and to test whether there is a relationship between accommodative response and myopic progression rate.

Methods: A cohort study was carried out to measure the accommodative response and myopic progression with time. We enrolled 38 mild myopic children (aged 10–13 years) with mean myopia -1.82 ± 0.75 D spherical equivalent. We compared the refractive error, ocular biometry and accommodative response between the first year's visits. Refractive error was determined by autorefraction after cycloplegia and ocular

biometry, by A-scan ultrasonography and accommodative response, by SRW-5001K (Shin-Nippon, Japan). Results were based on the right eye and analysed by using paired *t*- test and Pearson correlation.

Results: At baseline, accommodation response at far (6 m, ARF) and near (0.33 m, ARN) was 0.26 ± 0.31 D and 2.12 ± 0.28 D, respectively. At the 1st year visit, myopic progression was -0.76 ± 0.40 D. Difference of accommodation response at far and near was -0.17 ± 0.45 D ($t = -2.28$, $p = 0.029$) and -0.00 ± 0.39 D ($t = -0.05$, $p = 0.963$), respectively. There was no statistically correlation either between the myopic progression and ARF ($r = 0.16$, $p = 0.34$), ARN ($r = 0.22$, $p = 0.19$) or between the myopic progression and the average ARF ($r = 0.04$, $p = 0.84$), ARN ($r = 0.19$, $p = 0.26$).

Conclusion: With myopic progression, we find statistically significant decrease in the accommodation response at far but not at near. There is not a statistically significant relationship between myopic progression and accommodative response either at far or at near.

F047

Multifocal oscillatory potentials of stable and progressing myopes

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Purpose: Oscillatory potentials have been suggested to be an indicator of inner retinal activity and are thought to reflect the dopaminergic or GABAergic inhibitory feedback pathways initiated by the amacrine cells of the inner retina. We sought to compare the oscillatory potentials of the multifocal electroretinogram (mfERG) of adult emmetropes and myopes.

Methods: Eleven emmetropes and 18 myopes underwent mfERG testing using VERIS 5.1.5X. Myopes were further separated based on whether their myopia was stable ($n = 9$) or progressing ($n = 9$). Oscillatory potentials were recorded using a modified mfERG stimulation technique, the slow flash paradigm, and they were extracted using bandpass filtering from 100–300 Hz. The slow flash mfERG stimulus array consisted of 103-scaled hexagons and flickered according to a pseudorandom binary m-sequence (213–1). Amplitudes and implicit times of the first-order oscillatory potentials were analysed.

Results: Four distinct oscillatory potentials (OP1–OP4) were observed. There were significant differences in the implicit time of the oscillatory potentials of the three refractive error groups ($F2,25 = 5.896$, $p = 0.009$). Progressing myopes had significantly shorter implicit times compared to emmetropes ($p = 0.005$; by 2.9–7.7 ms) and stable myopes ($p = 0.048$; by 1.1–3.3 ms), whereas implicit times of stable myopes and emmetropes were similar. Implicit time differences were statistically significant for all four oscillatory potentials. There were no statistically significant differences in amplitude of the oscillatory potentials between the groups ($F2,25 = 0.508$, $p = 0.609$).

Conclusion: Significant multifocal oscillatory potentials differences between stable and progressing myopes were found. This finding is further evidence of an inner retinal involvement in human myopia progression and suggests an underlying alteration to the dopaminergic or GABAergic system.

F048

Diffraction induced visual colour discrimination

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Purpose: To explain the Colour Discrimination ability of the human eye by considering the diffraction of light at the pupil of the human eye.

Methods: Analytical solutions for Fresnel diffraction for circular apertures have been provided by Klaus D. Mielenz in Algorithms for Fresnel Diffraction at Rectangular and Circular Apertures (Journal of the NIST, V. 103, No. 5,Sept 1988). Using a proper choice of diffraction parameter values, the colour discrimination ability of the human eye is studied by calculating the frequency dependant intensity modifying values due to diffraction of light at the pupil. The final diffraction image is chosen to lie on the retinal surface where the intensity values are obtained.

Results: The intensity modifying values indicate that the colour discrimination ability of the human eye can be explained with a high degree of accuracy using this model.

Conclusion: The colour discrimination ability of the human eye such as the wavelength discrimination curve can be fully explained using a diffraction model.

F049

Dynamic blur perception in myopia

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Purpose: To develop quantitatively based conceptual models of dynamic blur perception in myopia.

Methods: Blur detection (depth of focus) and four successive blur discrimination (just noticeable difference in blur) thresholds in depth were assessed psychophysically at the fovea and in the near retinal periphery (up to 8 degrees) monocularly in young adult myopes ($n = 10$) with full optical correction and cycloplegia. Blur detection was also assessed after a 1-hour period of blur adaptation.

Results: Blur detection thresholds increased with retinal eccentricity (e.g. 0.9 D at the fovea and 3.5 D at 8 degrees for isolated aperture stimuli). Blur discrimination thresholds were smaller than blur detection thresholds by 40%. Thus,

blur discrimination was better than blur detection at each retinal eccentricity. Blur adaptation decreased blur detection thresholds by 20%. Thus, blur sensitivity was enhanced by blur adaptation. Blur thresholds were larger in myopic vs emmetropic eyes by 15% (0.08 D). Thus, myopic eyes were less sensitive to blur. Based on these experimental findings, a dynamic model of blur perception in myopia was developed using the concept of three-dimensional equiblur zones.

Conclusion: The zone of clarity within the depth-of-focus and these successive equiblur zones are dioptrically and physically larger in myopes than in emmetropes throughout their retinal extent. Furthermore, they are susceptible to modification, for example by blur adaptation. Under natural viewing conditions, dioptric/linear expansion and compression of these three-dimensional equiblur zones would occur with changes in external (e.g. retinal eccentricity/retinal-image extent) and/or internal (e.g. blur adaptation) factors. Thus, blur sensitivity and global blur perception is dynamic processes, and not static as suggested by control system models of accommodation.

F050

The measurement of peripheral aberrations with the complete ophthalmic analysis system (COAS)

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Purpose: To determine the feasibility and face-validity of peripheral aberration measurements using the Complete Ophthalmic Analysis System (COAS).

Methods: Thirty normal right eyes were measured using the COAS (WaveFront Sciences). Ten dilated measurements were made in central (along the line of sight), 30° nasal, and 30° temporal gaze. The subject's head was rotated while keeping the eye in primary gaze for peripheral measurements. Average OSA Zernike coefficients through 6th order were calculated in microns for a 6-mm pupil. Higher-order (HO) RMS (3rd through 6th order) was calculated. A repeated measures ANOVA was used to test for central, nasal, and temporal measurement differences for Z (2,0) (defocus), the astigmatism terms, the coma terms, the trefoil terms, spherical aberration, and total HO RMS. Correlations were calculated between nasal-to-central and temporal-to-central differences for defocus, the astigmatism and coma terms, and spherical aberration using a Bonferroni adjustment.

Results: A main effect of gaze was present in each repeated measures ANOVA (p-values <0.0001 to 0.038). Central, nasal, and temporal values for astigmatism, horizontal coma, and total HO RMS were all significantly different from each other as determined by Tukey's HSD post-hoc testing. Z^2_2 (with- and against-the-rule astigmatism) was greater nasally (mean ± SD; 0.3 ± 0.75) than centrally (−0.1 ± 0.63) and greatest temporally (1.6 ± 0.88). Z_2^{-2} (oblique astigmatism) was greater nasally (0.2 ± 0.58) and temporally (−0.4 ± 0.86) than centrally (-0.1 ± 0.60). Z_3^1 (horizontal coma) was greater nasally (0.6 ± 0.29) and temporally (−0.7 ± 0.32) than centrally (−0.0 ± 0.09). HO RMS was greater nasally (0.7 ± 0.26) and temporally (0.8 ± 0.32) than centrally (0.3 ± 0.11). All correlations between nasal and temporal differences were significant (p-values <0.0002) except vertical coma ($p = 0.12$).

Conclusion: Peripheral aberration measurements with the COAS are feasible and the results reasonable based on the principles of off-axis optics. The COAS can be used for future studies of peripheral image quality in the evaluation of emmetropisation.

F051

Reduced retrobulbar blood flow and ocular pulsatility in human myopia

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Objectives: To assess the ocular blood flow in the retrobulbar vessels (Colour Doppler Ultrasound, CDI) and retinal vessels (Heidelberg Retina Flowmeter, HRF), and ocular pulsatility (Ocular Blood Flow Analyser, POBF) of healthy myopes.

Subjects: A total of 86 healthy volunteers grouped into three mean sphere equivalent (MSE) bands: (i) high myopes ($n = 26$), MSE&# 8805; –5.00 D (average MSE –6.86 D ± 1.54; mean age 26.76 years ± 10.92); (ii) low myopes ($n = 30$) MSE –1.00 to –4.50 D (mean MSE –2.26 D ± 1.00; mean age 32.65 years ± 15.35); (iii) controls ($n = 30$), MSE&# 8804; –0.75 (mean MSE –0.14 ± 0.32; mean age 33.16 years ± 15.31). Groups were matched for age, gender and ethnicity. Axial length (AL), vitreous chamber volume (VCV), corneal thickness, blood pressure, intraocular pressure, and body mass index were recorded to evaluate potential correlations with ocular blood flow parameters.

Results: One-way ANOVA (Tukey *post hoc*) and Pearsons correlation test assessed the differences between the three groups evaluated and the strength of the relation between MSE and vascular parameters. Pulsatile ocular blood flow amplitude (POBFa), POBF volume (POBFv) and total POBF were significantly reduced in high myopes compared to emmetropes ($p = 0.024$; $p = 0.025$; $p = 0.017$). Higher resistance index (ri) in the Central Retinal Artery (CRA) together with an increased systolic/diastolic velocity ratio were found in high myopes compared to low myopes ($p = 0.002$; $p = 0.008$). MSE correlated with AL, VCV, POBFa, POBFv, total POBF and CRAri ($p < 0.001$; $p < 0.001$; $p = 0.027$; $p = 0.023$; $p = 0.01$; $p = 0.031$), implying a correlation between AL increase and OBFa reduction ($R2 = 0.38$; $p = 0.001$).

Conclusion: Retrobulbar blood flow and ocular pulsatility are reduced in the human myopic eye such that ocular flow reduction correlates with the axial length increase observed in myopia. These findings suggest that CRA and choroidal blood flow are reduced in myopia, but the retinal microvasculature is unaffected.

Poster Papers

P020

Central cornea thickness and its relationship with degree of myopia in Asian myopic adults

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Purpose: To investigate the relationship of central cornea thickness with the degree of myopia in an Asian population.
Methods: A retrospective cohort study: the subjects ($n = 714$) were recruited from a refractive clinic. The subjects' ages ranged from 15 to 59 years. Cornea topography was performed on the right eye of each subject. The central cornea thickness (CCT) was correlated with the degree of myopia.
Results: The mean CCT was 534.5 μm with a SD of 38.1 μm. The range was from 305 μm to 684 μm. The mean myopia was −4.88 dioptres (D) with a SD of 2.67 D (range −16.0 to −0.5 D). There was no correlation between CCT and the degree of myopia ($r = -0.13$, $p = 0.719$).
Conclusion: The mean CCT in Asian young myopic adults was much thinner compared with data in a Caucasian population. There was also a large range of central cornea thickness amongst these eyes.

P021

Axial growth and myopia progression with 7-methylxanthine. A double blind, parallel, placebo controlled clinical trial

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Purpose: To examine the effect of 7-methylxanthine on axial growth, myopia progression, and change in corneal curvature.
Methods: One hundred and seven children with a minimum myopia of −0.75 D in one eye (cycloplegic) were screened for excessive axial growth. 84 (age 8–13 years) found to have an axial growth rate of 0.15 mm or more per year were randomised to either placebo or 7-methylxanthine tablets, 400 mg every morning for 12 months. Axial growth, change in corneal curvature (Zeiss IOL-master), and cycloplegic myopia progression (Nikon Retinomax) was measured. Weight, height, blood pressure and heart rate was monitored. Participants were questioned for possible CNS, gastrointestinal or cardiopulmonal side effects. Approval: Danish Medicines Agency, Study ID Numbers: 2612–2320.
Results: 78 children completed the trial. Relative to base-line level, the axial growth rate was reduced to 75% in the placebo group compared with 91% in the placebo group ($p = 0.078$). Axial growth rate in the trial period was proportional to with base-line growth rate ($p < 0.01$). Among children with a base-line axial growth rate of less than 0.2 mm per six months ($n = 46$), axial growth in the 7-methylxanthine group was 0.192 mm compared with 0.247 mm in the placebo group ($p = 0.073$), and myopia progression 0.398 dioptres in the 7-methylxanthine group compared with 0.506 dioptres in the placebo group ($p = 0.227$). The change in corneal curvature was −0.006 dioptres in the 7-methylxanthine group compared with −0.054 dioptres in the placebo group ($p = 0.131$). In children with a base-line axial growth rate of 0.2 mm or more but less than 0.4 mm per six months ($n = 31$), the differences were less pronounced. One child had a base-line axial growth rate of 0.52 mm per six months and was outside the stratification layers.
Conclusion: The results from this double masked, parallel, placebo-controlled clinical trial support the hypothesis that systemic treatment with 7-methylxanthine normalizes the abnormal growth pattern of myopic eyes. Axial growth in the 7-methylxanthine group was reduced by 22% in the low axial growth stratification layer and by 8% in the high axial growth layer compared with placebo. The myopia progression in the two layers was reduced by 21% and 12% respectively.

P022

The prevalence of refractive errors in Iranian guidance

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Purpose: To investigate the prevalence of refractive errors in Iranian guidance school students, teenager between 12 and 16.
Methods: 1830 0f 20 000 guidance school students were selected by utilising clustering method and a visual acuity were measured by using snellen charts. Cycloplegic autorefraction of the low visual acuity was measured by the Nidek 8000 autorefractometer and types of errors were determined.
Results: 561 students (30.7%) with significant refractive errors were found that 457 students (24.4%) were ignored about their visual problems and 104 students (6.5%) wore glasses to cover their refractive errors. In 457 cases, myopia + astigmatism was the most conventional refractive error (160 students, 8.4%) and the next was hypermetropia (91 students, 5.0%) and the myopia was the least (69 students, 3.8%).
Conclusion: According to our finding the highest rate of the prevalence refractive error was 30.7% of the studied population (age 12–16) that just 5.6% of them had been distinguished before this study. So it will increase the risk to stabilise amblyopia in these ages. It shows the importance of careful screening examination. In our study, not only myopia but also

astigmatism that is associated with, are the most prevalent refractive errors among the selected population and it confirms previous finding that shows myopia as the most prevalent refractive error in the world.

P023

Preferred retinal locus in patients with high myopia

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Purpose: To study the preferred retinal locus (PRL) in patients with high myopia, and the role of new PRL development.

Methods: The PRL locations were determined by scanning laser ophthalmoscopy for both eyes of 57 patients (44 women, 13 men) with high myopia. The PRL were divided into three groups; those at the fovea (central fixation), established new PRL at an eccentric lesion (eccentric fixation), and pseudo-central fixation that tends to see the target at the central lesion without visual function. Chorioretinal atrophy (CRA) at the macula was examined by funduscopy. The eyes with worse visual acuity were defined as the non-dominant eyes.

Results: The 24 patients without CRA had central fixation. The 33 patients with CRA had CRA in at least one eye. In the patients with CRA, all eyes had central fixation in the non-dominant eyes with visual acuity of 0.3 or better; however, no eyes had central fixation when the visual acuity was 0.1. Ninety per cent of the non-dominant eyes had eccentric fixation when the CRA was bilateral; however, 40% had pseudo-central fixation when only one eye had CRA. All fellow eyes had central fixation when the non-dominant eyes had central or pseudo-central fixation, and 70% of the fellow eyes had eccentric fixation when the non-dominant eyes had eccentric fixation.

Conclusion: The PRL in patients with high myopia without CRA tended to remain at the fovea. The PRL in the non-dominant eye with CRA tended to follow the PRL in the dominant eye and was associated with visual acuity, the PRL in the dominant eye, and whether CRA was in one eye or both eyes. Determining the PRL in both eyes is essential when evaluating how patients with high myopia see their environment using binocular vision.

P024

Another look at the longitudinal orthokeratology research in children (LORIC) after 3 years

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Purpose: The LORIC study, a 2 year longitudinal study in Hong Kong SAR, has shown that orthokeratology (ortho-k) slowed myopic progression in 35 children wearing ortho-k lenses by about 50% when compared to children wearing spectacles in Hong Kong SAR.

Methods: This poster presents the changes in axial length of the ortho-k children, and comparisons made with the axial length findings of previous studies using other types of contact lenses and ocular drugs. The comparison included the axial length (ultrasound biometry) results of 17 of the ortho-k children (in the LORIC study) after 36–42 months of ortho-k lens wear.

Results: Compared to findings with soft and RGP lenses, atropine and pirenzepine, axial length elongation in the ortho-k children of the LORIC study at 6 months, 12 months, 24 months is much smaller. Axial length elongation for 17 children after wearing ortho-k lenses for 36–42 months was 0.39 mm.

Conclusion: Ortho-k lens wear slows myopic progression.

P025

The effect of progressive addition lenses on slowing evolutive myopia on Chinese children

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Purpose: To evaluate the effect of progressive addition lenses (PALs) compared with single vision lenses (SVLs) on the progression of Chinese juvenile-onset myopia.

Methods: Three hundred and three children enrolled (aged 6–15 years) with myopia between −0.75 and −6.00 D (spherical equivalent) in three research centres at Wenzhou, Shanghai and Beijing. They were randomly assigned to receive either PALs or SVLs, with 36 months follow-up visits. The primary outcome measure was the progression of myopia, as determined by subjective refraction at each visit. Other measurements included ocular axial length, phoria, reading distance and time, and physical development of children. The distance correction was determined by subjective methods before cycloplegia. Child-based analyses (i.e. the mean of the two eyes) were used.

Results: Data from Beijing centre were not included in the results due to significant bias in baseline refraction between two groups. Data were analysed on 95 children with PALs and 87 children with SVLs from Shanghai and Wenzhou. Mean ($\pm$SE) increases in myopia (spherical equivalent) were -1.76 ± 0.75 for PALs and -1.93 ± 0.95 D for SVLs. Myopia progression is significantly slower with PALs mainly during the first year ($F = 6.87$, $p = 0.010$). The benefit of PALs is really significant compared to SVLs on esophoric children and most specifically during the 6th month and 12th month of the first year ($F = 6.27$, $p = 0.015$ for the 6th month; $F = 5.80$, $p = 0.019$ for the 12th month).

Conclusion: Mean myopia progression in Asian children from 6 to 15 years old is 0.61 D per year. The myopia progression is significantly slowed with PALs mainly during the first year. PAL's benefit is significant for esophoric children on the whole duration of the trial. When a child grows rapidly, the vision should be concerned, and regularly visual examination is important. Further investigation is needed to evaluate performance according to near addition.

P026

Photochromic spectacle lenses improve visual symptoms without altering contrast sensitivity in myopic school children with atropine treatment

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Purpose: Atropine eyedrop is an effective drug to control myopia progression. However, the visual symptoms and fear of ocular photo-toxicity due to mydriasis are the major causes of high dropout rate and poor compliance. This study is to investigate the changes of visual symptoms and contrast sensitivity after wearing photochromic spectacle lenses in myopic schoolchildren with atropine treatment.

Methods: Twenty-four eyes of 12 patients who received low concentration of atropine for controlling myopia progression were enrolled. Before and 2 months after wearing photochromic spectacle, subjects completed a prospective questionnaire assessing the frequency of six visual symptoms (photophobia, glare, halos, near blurred vision, diplopia, and fluctuating vision). In addition, monocular contrast sensitivity function was measured to compare wearing non-chromatic trial lens and photochromic lens.

Results: Eighty-three per cent of patients found that photochromic spectacle lenses significant improved their overall visual symptoms. Four visual symptoms (photophobia, glare, halos, and near blurred vision) were statistically significantly improved after wearing photochromic spectacle lenses. In contrast sensitivity, there was no statistically significant difference in eyes wearing non-chromatic trial lens and photochromic lens.

Conclusion: This study demonstrates photochromic spectacle lenses do not reduce contrast sensitivity in myopia schoolchildren with atropine treatment. In addition, it suggests improvement of visual symptoms.

P027

The influence of myopia and task on near work posture in adults

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Purpose: A short reading distance has been shown to increase myopia progression in children. Moreover, myopic children have been shown to work closer than emmetropic children. This study investigated the effect of myopia on several postural parameters during three near work tasks in a sample of non-presbyopic adults.

Methods: Working distance, eye and head declination were measured in an adult cohort (age 23–44) of 10 myopes (−6.00 to −0.75 D) and 12 emmetropes (−0.50 to +0.75) by means of a Polhemus Fastrack system. Subjects had to perform a reading and a writing task at a desk and a reading task in an armchair while their posture was recorded continuously at 10 Hz.

Results: Working distance and head declination were task-dependent.

Conclusion: Task modified working distance and head declination significantly, but not eye declination. Previously reported postural differences between myopic and emmetropic children, especially shorter working distances, were not found in our adult sample. Therefore, shorter working distances could be associated with myopia progression.

P028

Sensitivity and specificity of Optomap for fundus screening in a Hong Kong Chinese population

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Purpose: To investigate the sensitivity and specificity of Optomap for fundus screening in a Hong Kong Chinese population.

Methods: Fifty-four eyes identified with retinal/choroidal signs and eight normal eyes were recruited from thirty-one Hong Kong Chinese subjects. Photodocumentation of fundal changes were taken by Optomap under an undilated condition before a dilated fundus examination. All Optomap images were acquired by a clinician under standard procedures, and all dilated fundus examinations were performed by another clinician utilising binocular indirect ophthalmoscopy and slit lamp ophthalmoscopy with a fundus lens. Then, Optomap images were evaluated by four investigators for identifying retinal features under masked conditions. All results were matched with the international classification of disease 9th version (ICD-9-CM) for each type of retinal feature, recorded in pre-designed form. Screening results were compared with those obtained using dilated fundus examination as the gold standard.

Results: The sensitivity and specificity of the Optomap averaged 76.4% and 71.9% respectively. The fundal signs commonly missed by all observers were white-without-pressure (1 case), lattice degeneration (2 cases), paramacular drusens (1 case), and pigmentary change (1 case). Paramacular drusens were detected by contrasting the red laser channel and green laser channel, while other missed fundal signs were located at far peripheral retina apparently outside the field of Optomap.

Conclusion: The sensitivity and specificity found in this study is similar to the previous report. The Optos non-mydriatic fundus imaging system is suitable in fundus screening.

P029

A newly recognised retinal lesion in pathologic myopia – optical coherence tomography to detect peripapillary neural tissue loss over the disc crescent

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Purpose: Optical coherence tomography (OCT) was used to detect peripapillary neural tissue loss (PPNTL) over the disc crescent in pathologic myopia. The retinal neural tissue loss located inside the disc crescent in pathologic myopia is a newly recognised fundus lesion.

Methods: Review of 12 eyes of 12 patients with peripapillary yellowish-white retinal lesions who underwent OCT for evaluation of the nature of PPNTL in pathologic myopia. OCT, fluorescein angiography, automated visual fields, axial length measurement with ultrasound A scan, and ultrasound B scan were performed.

Results: Thirteen eyes of thirteen patients were identified during a 16-year period to have findings characteristic of PPNTL. The mean age of the patients was 46 years. They were followed up for an average of 10 years. The mean spherical equivalent correction was −10.25 diopters (D) (range −6.0 to 16.0 D). The mean axial length was 28.9 mm (range 26.30–31.50 mm). In each case, OCT showed a complete retinal discontinuity in the PPNTL lesion. Automated visual field examination showed corresponding arcuate scotoma. During the follow-up period, the inner retina layer of the retinal defect margin was elevated by posterior hyaloid and partial retinal detachment developed in one eye.

Conclusion: PPNTL in pathologic myopia is a relatively asymptomatic, yellowish-white peripapillary retinal discontinuity. Recognition of this lesion is important because the visual field defect may mimic glaucomatous changes owing to the loss of nerve fiber layer. Progressive partial retinal detachment may ensue as one of the complications of the peripapillary lesion.

P030

Late results of sclera reinforcement surgery using synthetic grafts

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Purpose: To boost the stabilising effect of sclera strengthening intervention, it is expedient to use synthetic grafts that enable sustained biomechanical action. The objective is to use the efficiency of scleroplasty with synthetic grafts in late follow-up periods (up to 8 years).

Methods: Forty-eight patients aged 8–25 with progressive myopia from 5.5 D to 16.5 D and an average annual rate of progression of 1.3 D were given bandaging operations according to Avetisov and Tarutta (1981). The graft was made from Mersilene mesh consisting of polyester. Patient examinations included visual tests, autorefractometry, direct and indirect ophthalmoscopy, measurements of acoustic density of the sclera (ADS) and the anterioposterior axis (APA).

Results: In late follow-up, myopia stabilisation was observed in 90.1% cases. 9.9% cases showed a 2.8-time decrease of progression rate against presurgery period. APA remained stable in 90.0% cases, while ADS exceeded the presurgical value by 2.3 db in the posterior pole area and by 3.5 db in the equator. The use of these grafts brought about no negative dynamics to the condition of the eye fundus, which testifies to their favorable effect both on blood supply and biomechanical properties of eye shells.

Conclusion: Synthetic grafts enable sustained support and reinforcement for the scleral capsule and thus stabilise the myopic process.

P031

Changes of hemodynamic parameters of the eye as a result of low-power laser radiation treatment of progressive myopia using MACDEL-09

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Purpose: Low-power infrared transscleral laser radiation of the ciliary body was previously (E.P.Tarutta et al., 2004) shown to inhibit myopia progression or slow down its progression rate. The mechanism of this treatment effect, however, is not fully clear. Our purpose is to study the change of hemodynamic parameters of the eye after laser stimulation treatment of progressive myopia in children and adolescents.

Methods: Transscleral infrared low energy laser radiation treatment of the ciliary body (wavelength 1.3 mkm, power at scleral level 1.0-1.5 mWt) with MACDEL-09 was administered to 12 patients aged 7–12 with progressive myopia of 0.5-5.5 D. All patients were examined before and after a course of treatment (10 episodes in 10 days). Beside visual tests, autorefractometry, fundus examination, and accommodometry, we used a noninvasive method to measure the hemodynamic parameters. A multifunctional ultrasound diagnostic device VOLUSON 730 Pro (Kretz) provided with a linear transducer of 10-16 MHz frequency was used to evaluate blood flow by Color Doppler mapping. The parameters measured included maximum systolic and end-diastolic blood

flow velocities (Vs and Vd, respectively), the peripheral resistance index (RI) in the ophthalmic artery (OA), central artery of the retina (CRA), and short posterior ciliary arteries (PCA).

Results: All parameters measured were found to undergo changes. Vs, Vd and the mean velocity value in CRA increased from 10.1∀1.1 to 13.67∀1.4 cm/sec, 0.9∀0.08 to 2.2∀0.3 cm/sec and 3.8∀0.4 to 5.3∀0.6 cm/s, respectively. The mean blood flow velocity in OA and PCA also rose from 11.9∀1.2 to 15.2∀1.6 cm/sec and 6.8∀0.7 to 7.7∀0.8 cm/sec, respectively.

Conclusion: The improvement of hemodynamic parameters noted after low intensive transscleral laser stimulation course accounts for the positive effect of the treatment on the myopic process and justifies the use of the method for the functional therapy of progressive myopia.

P032

Optical coherence tomography in different stages of macular degeneration in pathologic myopia

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Purpose: Optical coherence tomography (OCT) was used to examine the pathological area of myopic macular degeneration of different stages of pathologic myopia.

Methods: Review of medical records of macular degenerations in high myopia patients, staging as: T1 (Tessellation 1), T2 (Tessellation 2), D1 (Lacquer crack), D2 (Diffuse atrophy), P1 (Patch atrophy 1), P2 (Patch atrophy 2), or MA (Macular atrophy), underwent high resolution OCT (Stratus OCT; Carl Zeiss Meditec Inc., Dublin, California, USA) scanning. The imaging was analysed together with slit lamp biomicroscopy, visual acuity examination, refraction status and axial length. Ninety-eight eyes of 49 patients were included in the present study.

Results: In T1 cases, normal retinal architecture and normal thickness were found. Normal retinal architecture but decreased thickness was found in T2. In some T2 cases, retinal schisis with contracted posterior hyaloid membrane were found without foveal elevation. In D1 cases, dimpling at lacquer crack area and thinning of overlying neural retina were found. D2 cases showed neural retina thinning and minimal to moderate foveal schisis. Foveal detachments were found in some cases. In some P1 cases, partial retinal detachment was found. P2 cases showed thinning of neural retina without schisis or subretinal fluid in most cases. If sparing of neural retina was found as an island between P2 atrophic patches, the vision would be spared. Macular atrophic cases showed choroid and sclera thinning in addition to neural retina thinning. Large choroidal vasculature was found to be associated with overlying atrophy of neural retina and RPE layers.

Conclusion: High resolution OCT is a useful imaging technique in distinguishing and staging the macular degenerations associated with high myopia. It is also helpful in its tissue implication in pathogenesis of myopic maculopathy.

P033

Differential diagnostic criteria of optic nerve head changes in the onset of glaucoma in patients with high complicated myopia

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Purpose: In combined pathology of the retina and optic nerve associated with myopia and glaucoma, the risk of visual function deterioration increases. The purpose of the study is to identify differential-diagnostic features of optic nerve head changes in the early phase of glaucoma accompanied with high-complicated myopia.

Methods: Thirty-two patients (54 eyes) have been examined. To evaluate the visual function, hydrodynamic parameters and the state of the eye fundus, we used vision tests, Goldman tonometry (with a 5g load), electronic tonography, biomicroscopy, gonioscopy, ophthalmoscopy, confocal laser scanning using the Heidelberg retinal tomograph, and perimetry using the Humphrey automatic perimeter.

Results: It has been established that the most informative differential-diagnostic criteria of glaucoma development in patients with complicated myopia are intraocular pressure (IOP) level higher than 19.0 mm Hg, circadian IOP oscillation over 3.0 mm Hg, prevalence of reduced peripheral vision boundaries in the nasal half, reduction of intraocular fluid outflow parameters, the increase of optic nerve head (ONH) area/volume ratio. In tomographic examination, a new parameter has been calculated: ONH volume (the total volume of excavation and the neuroretinal rim).

Conclusion: The value of the volume ratio of neuroretinal rim/excavation of less than 1.0 in any quadrant testifies to a possible glaucomatous change of ONH.

P034

Effect of 1% atropine with tinted progressive glasses in slowing the progression of myopia in children

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Purpose: Animal and human studies have suggested that 1% atropine ophthalmic solution has been used to decrease the progression of myopia in children. We evaluated the efficacy of 1% atropine in slowing myopic progression in children compared with controls.

Methods: Subjects were 119 myopic children, aged 5–12 years, were followed up for at least 1 year since August 2001. We prescribed 1% atropine with progressive glasses to the treated group (69 patients) and prescribed only glasses to the control

group (50 patients) with less than −5.00 diopters. The change of axial length and cycloplegic refraction by retinoscopy and autorefractometer between the two groups were evaluated. The treated group were subdivided into daily drop of 1% atropine treated group I (44 patients) and three times a week drop of 1% atropine treated group II (25 patients) for analysis. We also compared the treated group I with the treated high myopic group (15 patients) with the initial myopia of −6.00 to −8.00 diopters.

Results: The mean annual myopic progression and axial length change in the treated group I (0.192 ± 0.469 Day year^{-1}, 0.108 ± 0.181 mm year^{-1}) was significantly less than the control group (0.916 ± 0.496 Day year^{-1}, 0.407 ± 0.197 mm year^{-1}) ($p = 0.000$). The mean annual myopic progression between the treated group I, II also showed statistical difference (group I: 0.192 ± 0.469 Day - year^{-1}, group II: 0.419 ± 0.443 Day year^{-1}) ($p > 0.05$). There was a mean increase in myopia of 0.349 ± 0.463 Day - year^{-1} in the high myopic group. But no significant difference was noted between the treated group I and high myopic group.

Conclusion: Daily drop of 1% atropine ophthalmic solution with tinted progressive glasses was more effective in slowing myopic progression than the treated group II and control. The treated high myopic children also showed no statistical differences in effect compared to the daily drop of 1% atropine treated group

P035

The relation between growth of axial length and ocular wavefront aberrations in school children

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Purpose: To investigate the relationship between the axial length growth and ocular wavefront aberration in school children.

Methods: Japanese lower-grade school children aged 8–10 years ($n = 100$) were examined annually for three years. Axial length was determined by Zeiss IOL Master, and ocular wavefront aberrations were measured by Topcon KR-9000PW.

Results: Average axial length at the first year was 23.04 mm (±0.80), at the second year was 23.23 mm (±0.84), and at the final year was 23.47 mm (±0.93). Average refraction at the first year was −0.50 D (±1.02), at the second year was −0.56 D (±0.91), and at the final year was −0.76 D (±1.14). In the first year, there was greater lower order aberration; i.e., more myopia had greater axial-length elongation during the next 2 years. ($p < 0.01$) If the 0.5 mm over axial-length elongation occurred during this period, the children displayed a greater myopic refractive change.

Conclusion: The risk factor of axial elongation would be the greater lower-order aberration during the first year. This means that more myopic eyes tend to have greater axial elongation in school children.

P036

Myopic control of orthokeratology on children in Japan

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Purpose: Myopia is a common ocular disorder in Japanese. Overnight orthokeratology (ortho-k) is effective for myopic reduction and has been claimed to be effective in slowing the progression of myopia (myopic control) in children. This study was conducted to determine whether ortho-k can effectively reduce and control myopia in children.

Methods: A retrospective study of 34 eyes of 17 patients, with mean age of 11.1 (range 7–14), was conducted. The mean spherical equivalent (SE) was −4.60 D. The same orthokeratologist prescribed the ortho-K contact lenses (CL) for each patient. The changes of refractive errors were determined after the stable uncorrected visual acuity (UCVA) was achieved. The subjects were followed at least 2 years.

Results: All the ortho-k subjects found post-ortho-k UCVA acceptable in the daytime. The average follow up period was 38.1 weeks. The residual SE refractive errors (SER) at the end of the study were −0.42 ± 0.83 (mean ± SD) diopter (D). No significant SER change was found during the follow-up period.

Conclusion: These results indicated a corrective and preventive/control effect for myopia in Japanese children. Longer follow-up is necessary for long-term results.

P037

Scleroplasty in progressive myopia

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Purpose: To examine effectiveness and complications of scleroplasty in progressive myopia.

Methods: Homologous sclera was used as graft for scleroplasty. Scleral flap inserted, fastened around eye ball under muscles.

Results: Surgical treatment aimed at strengthening the sclera of myopic eye makes it possible to stabilisation of myopia. The complications related to this method of treatment are not comparable with the severe consequences of uncontrolled progressive myopia like chorioretinal dystrophy, retinal detachment and hemorrhages that causes deterioration of central and peripheral vision and are due to considerable enlargement of eyeball.

Conclusion: Simplicity of the technique, their safety and high efficiency make it possible to recommend the use of scleroplasty in children and adolescence earliest possible age when myopia progression begins from −6.00 D before any dystrophic changes can develop in fundus.

P038

To investigate relationship between macular retinal thickness and axial length in myopia

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Purpose: To evaluate the variation in macular retinal thickness in healthy Chinese myopic subjects by using optical coherence tomography (OCT). The relationship between retinal thickness and axial lengths were also analysed.

Methods: One hundred and six myopia patients (≥−0.75 D) underwent examination of optical coherence tomography (Zeiss–Humphrey OCT3000), IOLMaster and other primary ocular examination. Fast macular thickness map OCT scans of 6 mm were done well on each eye by same operator. The overall average fovea thickness, the mean retina thickness of superior, nasal, temporal and inferior parafovea, minimum retinal thickness (at the foveola) were recorded. The relationship between retinal thickness and axial length were analysed by simple linear regression. According to spherical equivalent (−6.00 D), put these eyes into two groups: medium myopia and high myopia group. And 22 emmetropic eyes was comparative group. The correlations among these groups were also analysed.

Results: (1) The mean retina thickness of parafovea correlated negatively with axial length, ($p < 0.05$). (2) there was no correlation among minimum retinal thickness, the mean fovea thickness and axis length of eye. (3) the minimum retinal thickness was 150.90 ± 22.10 μm, ($p < 0.05$). (4) the retina thickness at the superior, the inferior and nasal sides of parafovea was significantly thicker than the temporal one. (5) the mean retina thickness of parafovea in high myopia group were significant thinner than other groups, ($p < 0.05$). (6) there was no statistical difference between emmetropic group and medium myopia group.

Conclusion: The attenuation really existed in high myopia. It was in parafovea area but not fovea. With increase of axial length, the variation in thickness between foveal pit and parafoveolar crest decrease with myopia. OCT is an ideal method to observe this variety.

P039

A survey of the habits of myopic children in a Singapore paediatric clinic

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Purpose: (1) Discover how much time the child spends at various near work and outdoor activities after school hours. (2) raise awareness among parents to the amount of time the children spend indoors and on near work. (3) help ophthalmologist and parents check on the near work/outdoor activity ratio in order to encourage a healthy balance for the eyes.

Methods: (1) Informal Survey of myopic patients in a paediatric clinic over 9 months (June 2005–March 2006). (2) questionnaire regarding near work parameters (homework, computer, handheld games, television and reading) and outdoor activities and the hours spent doing each activity per day. (3) cyclopegic refraction.

Results: The pattern of time spent at each of the activities are shown with respect to the degree of myopia and age group, and the average amount of time spent on near work was 4.8 h per day while the amount spent on outdoor activities was much less, with an average of only 0.8 h per day.

Conclusion: Singapore has the reputation of having one of the highest rates of myopia among school-going children in the world. Much has been written about the association of myopia development with near-work activity. In this survey, the amount of time spent on near work was significantly more than that for outdoor activities. Hence in view of the possible link between near-work and myopia, there is a need to raise this awareness and encourage the young to engage in more outdoor activities as this is one possible modifiable risk factor for myopia.

P040

A study on refractive error, amblyopia and strabismus in Singaporean Chinese preschoolers (RASSE)

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Objective: The aim of this study is to determine the prevalence of refractive error, amblyopia and strabismus in Chinese children aged 6 months to 6 years.

Methods: A population-based prevalence survey will be conducted in the South-Western part of Singapore. The study area will be enumerated and interviewers will invite 3,000 eligible Chinese children aged 6 months to 6 years for an eye screening examination at a nearby clinic. Written informed consent is obtained from the parents in the clinic. Ocular examination includes visual acuity (without and with best-corrected glasses), Randot preschool stereoacuity test, colour vision, cover-uncover test, ductions and versions, fixation preference test, cycloplegic refraction, non-contact measurement of axial length, anterior segment evaluation, and fundoscopy. The children's height and weight will also be recorded, and parental interview will be used to assess children's diet and daily activities. In preparation for the study, a small pilot study was undertaken to test the study process. The study design is based on the Multi-Ethnic Pediatric Eye Disease Study (MEPEDS)

coordinated by the University of Southern California, Los Angeles.

Results: In our pilot study, all homes in 12 blocks around Radin Mas and Sunset Way districts were enumerated and 117 eligible Chinese children aged 6–72 months were found. 81 of the 117 (response rate = 69.2%) children agreed to be examined in the clinic. The main reasons for refusal to participate were the lack of time, and fear of cycloplegic drops. 27 families (37 children) were recruited into the study. The age of the children seen ranged between 7 months and 6.4 years (median 4 years). One child (2.8%) was noted to be amblyopic, and one child (2.8%) had an intermittent exotropia. The mean cycloplegic refraction was 1.3 ± 1.2 D in children ≤2 years (n = 12), 1.2 ± 0.8 D in children between 2.1–4 years (n = 12), and 0.4 ± 1.6 D in children >4 years (n = 13). Three children had astigmatism ≥1.5 D in at least one eye; and two children had anisometropia ≥1.5 D between eyes. No anterior segment abnormalities were noted in any of the children. Myelinated nerve fibres were noted in the fundi of one child, and increased cup-disc ratio in another.

Conclusion: Very little is known about the prevalence of eye disease in preschool children, and no study of this type was ever been attempted in Singapore. It is hoped that this study will provide answers. By adopting the established protocol of other groups, comparison will be possible between children of different ethnic groups and countries.

P041

The impact of intraocular pressure and ocular dominance on the progression of acquired myopia: one year report

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Objectives: To evaluate the possible impact of intraocular pressure and ocular dominance on the progression of acquired myopia.

Methods: Mild acquired myopic children with anisometropia 1.5 D were enrolled for a cohort study. At each semi-annual visit, introcular pressure (IOP) was measured with Goldman Tonometer (Swiss) in the same time course of a day. Ocular dominance was determined by using the hole-in-the-card test and progression of myopia, by autorefraction after cycloplegia. Covariance analysis was used to analyse the difference of myopic progression, average IOP between eyes and the ocular dominance.

Results: Seventy-eight children (male 37, female 41) mean aged 10.99 ± 1.56 years, completed the three visits in the first year's observation. There are 46 right eye preferents and 32 left eye preferents. Mean spherical equivalent refractive error (SER) of right and left eye were −1.76 ± 0.72 D and −1.75 ± 0.70 D respectively, and mean anisometropia was 0.01 ± 0.31 D at baseline. During the first year, average IOP and myopic progression between eyes were 14.54 ± 2.11 mmHg, 14.61 ± 2.08 mmHg and −0.71 ± 0.33 D and −0.72 ± 0.36 D, respectively. The F value between the difference of average IOP and of myopic progression is 0.208 (p = 0.650), and 2.15 (p = 0.147) for the difference of myopic progression and ocular dominance.

Conclusion: To the mild acquired myopia without severe anisometropia, one year's observation does not indicate that IOP plays a role in myopic progression, nor ocular dominance. However, we suggest longer observation is necessary to determine the longer term impact of IOP and ocular dominance on the myopic progression.

P042

Investigation of near accommodative facility in younger and older myopic children

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Objectives: To study the effect of age on near accommodative facility in younger and older myopic children.

Methods: 54 myopes and 59 emmetropes between age group of 8 to 18 years without any binocular vision anomalies and any ocular diseases were enrolled for the study. All subjects underwent detailed ocular examination and cycloplegic retinoscopy. Near accommodative facility was measured with +/−2.00D accommodative flippers with best refractive correction over one minute period. Subjects were divided into two different age groups - group 1: subjects with <12 years of age and group 2: subjects aged 12 years or more. Mean spherical equivalent refractive error in myopes was -2.70DDS (SD +/−1.7DS) in right eye and -2.86DS (SD +/− 2.14DS) in left eye. Mean spherical equivalent refractive error in emmetropes was 0.29DS (SD +/−0.33DS) in right eye and 0.29DS (SD +/−0.33DS) in left eye.

Results: Data was analyzed with accommodative facility as dependent variable and age and refractive error as independent variables. There was a significant influence of age on binocular near accommodative facility ($p = 0.02$). Refractive error also showed significant influence on binocular near accommodative facility ($p < 0.0001$) in both groups. There was a significant interaction of age and refractive error together on binocular near accommodative facility ($p = 0.003$).

Conclusion: Our results suggest that young myopic children have significantly lower near accommodative facility than emmetropic children. Older children show no significant difference.

18 August 2006, Friday – Day 3

Plenary Lectures

PL005

Myopia studies in an animal that cares little about refractive errors: the mouse

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Purpose: To explore the advantages and disadvantages of the mouse as a model for myopia.

Methods: Refractive state – automated infrared photorefraction, corneal radius of curvature – automated photokeratometry (both laptop-based with infrared-sensitive firewire cameras), ocular dimensions – optical low coherence interferometry (OLCI, Zeiss ACMaster), grating acuity and contrast sensitivity – automated optomotor task, retinal transcripts and protein expression – real-time PCR and immunohistochemical labelling, glucagon and atropine application – eye drops. Finally, Egr1-knock-out mice were studied.

Results: In C57BL/6 mice, the SD of repeated refractions was 2.7 D (range of inter-individual variability). In Egr1-knock-out mice, variability among individuals was high enough to evaluate reliability - correlation of repeated measurements $p < 0.0001$. High inter-ocular correlations of OLCI demonstrates its reliability (SD about 10 μm). Optomotor and optical measurements indicate a depth of field of at least ±10 D – only high power spectacle lenses may have an effect. Wildtype mice respond poorly to deprivation with frosted occluders (3–4 D after 2 weeks), but both mRNA measurements and immunohistochemistry of Egr1 show highly significant changes in the retina after only 30 min (control eye covered with an attenuation-matched ND filter). Homozygous Egr1-knock-out mice had longer eyes and were more myopic than heterozygous and wildtype controls, but optomotor acuity was normal. Finally, atropine 1%, applied every evening as eye drops for 3 weeks reduced axial eye growth, but there was no effect of glucagon.

Conclusion: The mouse is a poor model for studying the relationship between visual experience and eye growth. However, it is a useful model for studies on the effects of (1) visual experience on retinal transmitters, (2) knock-out of candidate genes on eye growth, refraction, visual performance, and gene expression, (3) drugs on eye growth and mRNA/transmitter/proteins expression, (4) microarray analysis.

PL006

Accommodation: mechanism, dynamics, biomechanics, optics and myopia

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Purpose: A link between accommodation and myopia has long been suspected. Although it is generally understood that retinal image blur associated with accommodative lag may be the primary association, it is of interest to understand the accommodative mechanism, biomechanics, dynamics and optical changes that occur in the eye to better understand the association between accommodation and myopia.

Methods: Studies have been undertaken in anaesthetised, iridectomised rhesus monkeys in which accommodation is stimulated via an electrode in the Edinger-Westphal nucleus of the brain and in conscious human subjects accommodating to visual stimuli. A variety of dynamic refraction measurement and ocular imaging modalities have been employed to understand the accommodative mechanism and the accommodative biomechanical, dynamic and optical changes.

Results: Ciliary muscle contraction results in an anterior inward excursion of the apex of the ciliary body. This releases zonular tension at the lens equator and allows the lens capsule to mold the lens into an accommodated form with a decrease in lens equatorial diameter, an increase in lens thickness and a greater increase in lens optical power near the axis than at the periphery. Across the full-iridectomised entrance pupil diameter, ocular aberrations in monkey eyes increase during accommodation. Anaesthetised rhesus monkeys and conscious human subjects show no signs of accommodative fatigue and are capable of repeated accommodative responses.

Conclusion: Ciliary muscle contraction produces highly coordinated dynamic, biomechanical and optical changes in the lens to allow the eye to focus at near. It is tempting to speculate on whether myopia progression associated with a lag of accommodation may be due to increased ocular aberrations during accommodation from a breakdown in this highly coordinated physiological/optical process.

Symposium Papers

S029

Multilevel modeling of the effects of ethnicity, gender, and age of onset on progression of myopia in the CLEERE study

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Purpose: Ethnicity, gender, and age of onset are known to influence myopia progression. Models that quantify the effects of these factors could be very useful for predicting or comparing the behavior of various samples of children. The purpose of this analysis is to present a quantitative model of myopia progression.

Methods: Refractive error was assessed annually in the CLEERE Study by cycloplegic autorefraction. Children were from four ethnic groups (African American, Asians, Caucasian, and Hispanics) in grades 1 through 8. There were 238 myopes (at least −0.50 D spherical equivalent) who had at least one non-myopic visit prior to myopia onset and at least three post-onset visits. Multilevel, or hierarchical, modeling was used to describe progression rates. This strategy focuses on fitting subject-level models while explaining variation in model parameters using ethnicity, gender, and age at onset. Three terms were fit in an exponential decay model of progression: A (refractive error at onset), B (coefficient for the rate of decay), and C (amount of myopic change after onset). Refractive Error = C {1–exp [–B (years after onset)]}–A.

Results: Gender was the only significant factor for the onset term (females with more myopia at onset by −0.11 D) and for the rate of decay (females with a faster rate of progression). The exponential term for rate of decay, or progression, was not affected by ethnicity. However, the final amount of progression was related to ethnicity with Asians undergoing the most progression, Blacks the least, and Whites and Hispanics intermediate amounts of progression. Earlier age of onset resulted in a greater amount of progression, but did not affect the exponential rate of progression.

Conclusion: As expected, Asian ethnicity, female gender, and earlier age of onset each affected myopia progression. More importantly, the multilevel approach provided a quantitative, flexible description of progression capable of capturing and comparing the effects of any combination of the factors that affect progression.

S030

Visual impairment and refractive error among school children in Malaysia

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Purpose: Refractive error is one of the commonest causes of visual impairment in Malaysia (48.3%, National Eye Survey 1996). Reliable data on refractive error in children is needed for the planning of an effective school health programme. A population-based study in children 7–15 years of age was conducted in Gombak District form March to June 2003 to determine the age and sex specific prevalence of visual impairment and refractive error.

Methods: Cluster sampling was used to select eligible children. 8592 households were enumerated in 35 clusters. The visits to these households yielded 5537 children. Eye examinations were performed at the school attended by these children.

Results: A total of 4634 children were examined (participation rate 83.8%). Among those examined, 90% of the children have presenting vision of 6/9 and better in at least one eye. Prevalence of refractive error was 20.21% and amblyopia was 0.65%. Prevalence of myopia was 19.3% (95% CI 15.9, 22.8), hyperopia was 1.3% (95% CI 0.9, 1.7) and astigmatism of 0.75 D or greater was 15.7%. Prevalence of myopia was 13.9% in Malays, 45.2% in Chinese and 15.4% in Indian children. The prevalence of myopia increased from 9.8% at age 7 to 34.4% at age 15. Half of the children with refractive error did not wear or have glasses.

Conclusion: Prevalence of refractive error in children in Malaysia is the highest compared to similar studies done in Nepal (1.58%), China (11.3%), Chile (9.84%), urban India (7.26%), and rural India (2.65%). With half of the children who has refractive error did not wear glasses, refractive error among Malaysian children is indeed a significant public health problem. The school vision-screening programme has to be evaluated and improved.

S031

Myopia, reading and school attainment at age 7

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Purpose: Epidemiological data from the US and from East Asia suggest that reading is an important risk factor for myopia. We used data from an ongoing birth cohort study to investigate the associations between reading and myopia in young school-aged children taking part in a UK birth cohort study.

Methods: Non-cycloplegic autorefraction data were available for approximately 7000 children at the age of seven. We used as outcomes results from a standardised test of reading (the WORD test) carried out in the study clinics and the results of nationally administered assessments of reading carried out in schools (the SATS test). We also included data from self-completion questionnaires sent to the parents.

Results: Children who were myopic (−1.5 D or more) at seven read more words accurately than their non-myopic peers – mean difference 4.6 words (2.4–6.0); p < 0.001, after adjustment for sex, maternal education, breast-feeding and birthweight. Myopic children (−1.5 D) were also more likely to score well in their standardised school examinations, than their non-myopic peers, after accounting for sex, maternal education, breast-feeding. Adjusted OR 2.4 (1.5, 3.9); $p = 0.001$. This was unaffected by adjusting for verbal IQ; adjusted OR 2.7 (1.4, 4.9) $p = 0.002$.

Conclusion: These data suggest that in this UK cohort, as elsewhere, greater reading ability is associated with being myopic, even after adjustment for intelligence. As this relationship is already established by age seven, research is needed to investigate which factors in early life are involved, to determine whether preventative strategies may be possible.

S032

A cohort study of anisometropia in Singapore school children

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Purpose: To document the incidence rates of anisometropia, year-by-year prevalences, changes in the inter-eye difference in spherical equivalent (SE), and its associations with myopia progression and axial length changes in a cohort of Singapore school children.

Methods: This is a prospective cohort study of Singapore school children ($n = 1979$) aged 7–9 years, followed with annual cycloplegic refraction and ultrasonography over 3 years.

Results: For the 1908 children without anisometropia at commencement, the 3 year cumulative incidence rate of anisometropia (SE difference at least 1.0 D) was 144/1908 or 7.55% (95% CI: 6.42–8.85). The mean difference in SE between the two eyes for all children in the baseline measurement was 0.29 D (SD: 0.46), rising to 0.44 D (SD: 0.59) on the last examination. On the initial examination, 3.6% (95% CI: 2.8–4.4) or 71 children had anisometropia. 59/71 of these children completed all examinations, only 3/59 (5.1%) had an increase in the inter-eye SE difference by at least 0.5 D, whereas 2/59 (3.4%) had a decrease of at least 0.5 D. The mean inter-eye difference in SE was stable between visits. The change in inter-eye SE difference was correlated with the change in inter-eye axial length differences ($r = 0.43$). Compared to isometropic children, each eye of anisometropic children had a higher rate of myopia progression.

Conclusion: The 3 year incidence of anisometropia is 7.55% in young Singaporean children. Although the frequency of anisometropia increases with time, the SE difference between eyes tends to remain stable.

S033

Childhood myopia: a PMT perspective for improving health marketing communications

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Purpose: While much clinical research has been done on myopia, there is limited research on myopia prevention from a social marketing perspective. We bridge this gap by examining the role of parents in myopia prevention. Applying the Protection Motivation Theory (PMT) framework, we seek to understand the drivers behind parental intentions and actions in protecting their children from myopia.

Methods: An integrative model for myopia prevention behavior of parents was first developed in the context of theory and questionnaire surveys then refined using information gathered from two focus groups. Empirical data was then collected from parents of primary school children aged 8–11 in Singapore, a country with one of the highest rates of myopia in the world, and analysed using Structural Equation Modeling (SEM).

Results: Our findings revealed that coping appraisal variables were more significantly associated with protection motivation, relative to threat appraisal variables. In particular, perceived self-efficacy was the strongest predictor of parental intention to enforce good visual health behaviors, while perceived severity was relatively weak. We also compared the two groups (myopic vs non-myopic families) on the various dimensions measured. The two groups were similar on responses to all items except Vulnerability where parents of myopic children showed greater vulnerability M (Myopic) = 5.04 vs the parents whose children did not suffer from myopia M (non-Myopic) = 4.04 ($p < 0.05$).

Conclusion: The findings indicate that the PMT withstood the initial test of its structure in examining myopia prevention behavior. Support was found for the relationship between the threat appraisal variables, perceived severity and perceived vulnerability, with protection motivation. We also identified the influence of the coping appraisal variables, response efficacy and self-efficacy, on protection motivation. Self-efficacy was found to be a strong predictor of protection motivation. Interestingly, the coping appraisal components of the model exhibited stronger associations with protection motivation than did the threat-appraisal cognitions. We suggest implications for health marketing campaigns to promote myopia prevention.

S034

Regulating scleral signalling to control myopia

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Purpose: The biochemical and biomechanical remodeling of the sclera underpins the increase in eye growth that accompanies myopia. Numerous studies have detailed biochemical

changes in scleral extracellular matrix (ECM) proteins and regulating enzymes. In addition, the sclera's biomechanical properties undergo significant weakening during myopia development. It is generally accepted that these changes arise from a local retino-scleral signaling cascade. This presentation will investigate the role of regulators in controlling scleral remodeling during myopia development.

Methods: Tree shrew scleral fibroblasts were grown in culture and exposed to varying concentrations of TGF-β. Growth factor-induced regulation of scleral fibroblast contraction was measured in a three-dimensional collagen matrix, while the ECM protein synthesis was assessed using radiolabelled isotope incorporation. The expression of the myofibroblast cell marker, alpha smooth muscle actin (α-sm actin), was investigated using immunohistochemistry and real-time PCR. Monocular deprivation of pattern vision was used to induce myopia for 1 or 5 days and α-sm actin and TGF-β gene expression levels were measured using real-time PCR.

Results: Tree shrew scleral fibroblasts were highly contractile in culture, exhibiting a biphasic response (rapid contraction, 6%/h; slow contraction, 0.29%/h). Addition of TGF-β dramatically increased ($\sim$600%) the ability of scleral cells to contract the matrix, whilst also altering ECM protein production. An increase in the gene and protein expression of α-sm actin was also observed after TGF-β exposure. The *in vivo* expression of TGF-β and α-sm actin were altered after 1 and 5 days myopia induction and when this was modeled *in vitro*, a 25–40% decrease in cell contraction was observed.

Conclusion: Scleral regulators such as TGF-β, have roles in controlling the biochemical and biomechanical remodeling during myopia development, possibly via altered myofibroblast differentiation. The identification of such regulating molecules may provide a novel therapeutic target to control the scleral remodeling that results in high myopia.

S035

The signal pathways underlying ocular growth regulation

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Purpose: A pre-requisite to the development of effective therapeutic strategies for myopia is an understanding of how ocular growth and refractive errors are regulated. A map of the signal pathways involved in eye growth regulation will be developed from a review of the relevant literature.

Methods: Studies combining visual manipulations and lesioning procedures (optic nerve section, ONX; ciliary nerve section, CNX; intravitreally injected neurotoxins), will be reviewed, with emphasis on but not be restricted to studies involving the chick, the most widely used animal model in such studies.

Results: In chicks, ONX leaves experimental myopia unaffected, implicating local ocular mechanisms. CNX studies indicate a role for accommodation in decoding of optical defocus. Studies using neurotoxins suggest there are more than one local retinal signaling pathways, e.g. intravitreal 6-OHDA prevents form deprivation- but not lens-induced-myopia and glucagonergic amacrine cells survive intravitreal quisqualate but sign-dependent differences in the responses to imposed defocus are lost. A functional retinal pigment epithelium (RPE) is a pre-requisite for most experimentally induced growth changes although eyes continue to grow after chemical ablation of the RPE, e.g. with formoguanamine, pointing to additional systemic influences on eye growth.

Conclusion: Ocular growth regulation is likely to involve both local ocular as well as systemic mechanisms, with the former playing key roles in visually-mediated growth changes. In the retina, at least two subtypes of amacrine cells are likely to be involved, with the retinal pigment epithelium serving as a relay station for growth modulatory signals passing from the retina to the choroid and sclera.

S036

Ionic basis of fluid movements in refractive compensation to optical defocus

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Purpose: Form deprivation myopia is characterised by large ocular volume, abnormally elongated vitreous chamber and thinner choroid and is associated with significantly elevated sodium (Na), chloride (Cl) and potassium (K) ions (Crewther ARVO 2005). This led us to hypothesise that refractive compensation to negative and positive optical defocus should also lead to significant changes in retinal ion abundance to accompany the differential changes in ocular volume. Thus the aim of this study was to use X-ray microanalysis (XREM) to investigate ion abundance and to use immunohistological localisation for evidence of changes in fluid movements in the retina and choroid retinae of hatchling chicks raised with optical defocus.

Methods: Chickens were raised for 72 h post-application with monocular spectacle lenses of ± 10 D. Pieces of central retina were freeze dried and prepared for scanning electron microscopy and XREM using sequential scans every 20 μm across the retina from the retinal pigment epithelium to ganglion cell layer. Immunohistochemical localisation was used to examine the distribution of aquaporins AQP4.

Results: Comparison of the ratio of lens wearing eye to fellow eye Na, Cl and K ion concentration shows a sign dependent differential pattern across the retina after 72 h of lens wear. Significantly higher density of AQP4 is seen close to the vitread surface in the defocus induced myopia than in defocus induced hyperopia.

Conclusion: Refractive compensation to optical defocus is associated with differential changes in ion concentrations across the retina and changes in density of the specialised water channels, the AQP4s, along the Mueller cells.

S037

Differential protein expression in tree shrew sclera during recovery from lens-induced myopia

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Purpose: The tree shrew model of refractive development is particularly useful because, like humans, tree shrews have a fibrous sclera. Selective changes in some candidate extracellular matrix proteins and mRNAs have been found in the sclera during the development of, and recovery from, induced myopia. We undertook a more neutral proteomic analysis using two-dimensional gel electrophoresis and mass spectrometry to identify scleral proteins that change during the recovery from lens-induced myopia.

Methods: Five tree shrews (*Tupaia glis belangeri*) wore a monocular −5 D lens for 11–13 days, starting 24 days after natural eye opening, followed by 4 days of recovery without the −5 D lens. This recovery period was chosen because mRNA studies had previously shown significant expression changes at this time-point. Scleral proteins were then isolated and resolved by two-dimensional gel electrophoresis. The resulting protein profiles were compared using Progenesis™ 2D analysis software to detect protein spots that were differentially represented between fellow treated and control eyes.

Results: The scleral protein profile typically displayed ~700 distinct protein spots within the pH 5–8 range. Comparison of the five treated-eye and control-eye scleras revealed three spots that were significantly differentially expressed in all five pairs of eyes, two were down-regulated 1.8 and 2 fold respectively in the treated eye and one was slightly up-regulated 1.3 fold. These proteins are currently being identified by liquid chromatography tandem mass spectrometry (LC-MS/MS) and may include different proteins than were found to be down-regulated after 4 days of −5 D lens wear (Frost & Norton, ARVO 2006 E-abstract 1148).

Conclusion: Because the recovery from lens-induced myopia is within the physiologically normal range of the eye, one would expect few high-magnitude changes in the scleral protein levels, which was confirmed by the present results.

S039

Twins and myopia: PAX6 and beyond

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Purpose: The Twin Eye Study was established to identify the role of genes in common eye diseases, treating them as complex traits. Objectives were: (1) to establish the heritability of refractive error. (2) to perform a genome-wide linkage analysis of the trait. (3) to perform candidate gene combined linkage and association. (4) to identify replication of candidate genes and linkage studies. (5) to perform a SNP association analysis of PAX6 gene within the SCORM cohort.

Methods: (1) Intrapair correlations within over 500 pairs of twin's aged 50–79, 226 monozygotic and 280 dizygotic twin pairs, were performed and statistical modelling of covariance used to establish heritability. (2) linkage analysis using refractive error as a quantitative trait using a generalised linear modelling technique robust to deviations from normality was performed on 221 dizygotic twin pairs. (3) linkage and association analysis using QTDT was performed for the PAX6 candidate gene. (4) replication of the genome-wide analysis was performed using postal questionnaire in a different subset of twins, and comparison with other genome-wide scans. (5) an association analysis of PAX6 gene and refractive error was performed within the SCORM cohort, using longitudinal data.

Results: (1) Heritability was 85% for refractive error in this cohort. (2) genome-wide scanning revealed five highly significant linkage loci, with the highest LOD score of 6.1 on chromosome 11p13. (3) tagged SNP analysis of the PAX6 gene under the peak at 11p13 confirmed linkage but found no association with refractive error in the twin cohort. (4) Further genome wide scanning has replicated several areas, including chromosome 3q26. (5) although there was no significant association between individual SNPs within PAX6 and its flanking regions and refractive error within the Singapore cohort of children, there were significant associations with variables denoting the interaction between time and several SNPs ($p < 0.01$).

Conclusion: Genes are important in explaining the variation of refractive error within populations, with a heritability of over 80% in several twin studies. There are now several loci of interest within the human genome, which await replication from other studies, including twin and population-based studies. Although no definitive genes have yet been identified causing a susceptibility to myopia, the possibility that postnatal regulation of PAX6, a gene fundamental to eye development, may be involved in regulation of eye growth is suggested by the longitudinal data from the SCORM Study.

S040

All-trans-retinol dehydrogenase (RDH8) is not associated with high myopia

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Purpose: Retinoic acid level in the retina/choroid was found to change in induced myopia model. All-trans-retinol dehydrogenase (RDH8) is an important enzyme of retinoic acid metabolism. Non-syndromic high myopia is a complex trait and family-based association study is a powerful approach to mapping the susceptibility genes. This study aimed to investigate the association of the RDH8 gene with high myopia in a group of Han Chinese nuclear families with high myopic siblings.

Methods: Three single nucleotide polymorphisms (SNPs) were selected on the basis of the linkage disequilibrium (LD) pattern of the RDH8 gene from a previous study, and genotyped using a method based on denaturing high performance liquid chromatography among 128 Han Chinese nuclear families with highly myopic (−10 diopters or worse) offspring. The Haploview package was used to measure the pairwise LD among the three marker SNPs. Family-based association analysis was performed using the FBAT package, and genotype relative risk (GRR) calculated using the GENASSOC program.
Results: The three marker SNPs were all in linkage equilibrium with each other. SNPs RDH851 (rs2233789) and RDH8E5a (rs1644731) both did not show association with high myopia. SNP RDH855b demonstrated significant association ($p = 0.0269$) with a GRR of 0.543 (95% confidence intervals = 0.304–0.968, $p = 0.038$). However, the association became statistically insignificant after multiple comparison correction. Haplotype analysis did not show significant association either.
Conclusion: The RDH8 gene was not associated with susceptibility to high myopia. Thus, it is unlikely that RDH8 plays a major role in high myopia in the Han Chinese population.

S041

Is the pattern of refractive errors in adults an age-related of cohort effect?

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Purpose: Recent population-based studies in adults demonstrate a distinct pattern of refraction in middle-aged and older people. There is an initial hyperopic shift with age from 40 years to 70 years, following which there is a myopic shift in older people. It is unclear if this pattern might be related to a cohort effect (differences in prevalence of myopia and hyperopia between younger and older generations), longitudinal changes in refraction with age, or a combination of both.
Methods: We reviewed data from several new population-based studies that had refraction and ocular biometry data to examine the changes in refraction with age.
Results: Cross-sectional data from the Tanjong Pagar Study in Singapore demonstrate greater myopic refractions and shorter axial lengths in older as compared to younger people, a finding that supports a cohort effect, since axial lengths do not vary substantially in adults. However, data from Mongolia and the Los Angeles Latino Eye Study showed no difference in axial lengths in younger and older people, suggesting that this cohort effect may not be present in other racial/ethnic groups. Additionally, longitudinal data from white populations in the Beaver Dam Eye Study in Wisconsin and the Blue Mountains Eye Study in Australia showed an overall 5-year hyperopic refractive change of between +0.1 to +0.2 diopters. In adults less than 65 years, the refraction became more hyperopic, but in older people 65 years and older, the refraction became more myopic. Data from these studies therefore suggest the presence of a small but real longitudinal change in refraction with increasing age.
Conclusion: These studies support the concept that the pattern of refractive change in adults is a combination of a cohort effect and longitudinal changes in refraction, and may vary in different racial/ethnic groups.

S042

How well can people report refractive error changes?

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Purpose: A number of studies have relied on patient-reported changes in refractive error as a surrogate measure for the progression of myopia. We compared self-report of refractive error changes with documented retrospective data in a group of adult myopes.
Methods: The Study of Progression of Adult Nearsightedness (SPAN) is a 5-year prospective study of 25–35 year old myopic adults to investigate the risk factors associated with progression. At their 2003 visit, study patients completed a survey that included the question (adapted from Loman *et al*., 2002): 'During the past 5 years, has your glasses or contact lens prescription changed?' The possible responses were: yes, needed stronger; yes, needed weaker; yes, but not sure how; and no change. Patients were also asked to sign a release form and give the name and address of their most recent eye care practitioner. If a patient signed the form and identify a practitioner, a letter was mailed to his/her practitioner requesting his/her refractive error history. Patients were then identified who had three or more refractions and who had four or more years of follow-up. Progression was defined −0.50 D or greater and data were analysed for the right eye only.
Results: Refractive error data were obtained for 302 of the 373 patients who signed the release form and gave the name of their practitioner. Four or more years of follow-up data were available for 113 patients of whom 38 (34%) had progressed by at least (0.50 D and 75 (66%) had not progressed based on this criterion. Among the progressors, 23 (82%) believed that their prescription had increased and a further 3 (11%) stated their prescription had changed, but did not know the direction of the change. Among the non-progressors, 33 (51%) believed that their prescription had increased and 14 (22%) reported a change but did not know the direction.
Conclusion: The question 'has your glasses or contact lens prescription changed?' has good sensitivity, i.e. most subjects whose prescription has changed report this change. The question has poor specificity, however, with over half of those subjects with no documented change in their prescription reporting an increase. Care must be exercised in relying on patients' self report of refractive error changes.

S043

Mathematical modeling suggests two subpopulations in the etiology of myopia

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Purpose: To model the distributions of refractive errors in a variety of populations and use the shape of these distributions and changes in their shape to reveal the nature of mechanisms causing myopia.

Methods: Refractive data from preschool, illiterate, and highly educated samples in the United States, Europe, and Eastern Asia have been fit with multiple Gaussian distributions in which mean and variance, leptokurtosis, and skew are varied to produce a best fit with the data.

Results: Data from samples of preschool children show unskewed, highly leptokurtic refractive distributions with a mean Rx of +0.25 D to +0.50 D. Refractive distributions of illiterate adult populations are very similar. On the other hand, highly educated Eastern Asian samples have a high prevalence of myopia and are best represented by the sum of two Gaussian distributions, one of which is leptokurtic and spreads only slightly toward myopia while the second is a Gaussian distribution with a mean between −3.00 D and −5.00 D. Refractive distributions from educated populations in Europe and America can be described as either skewed toward myopia with the peak value shifting slightly toward myopia or by the summed distributions with only a small portion of the sample in the second large myopic shift group.

Conclusion: Modeling refractive distributions may reveal the nature of mechanisms inducing myopia. In educated Eastern Asian populations there appear to be two groups, one resistant to myopia and the second prone to a strong shift in the myopic direction when triggered by factors in the environment. In Europe and America a smaller portion of the population is in the second group. Distributions in the intensity of environmental triggering factors such as reading or education cannot predict the dual population distribution model. The most parsimonious suggestion is that one group (the majority in the West) is genetically resistant to myopia while the second lacks this genetic defense.

S044

Health belief of Singaporean Malays with undercorrected refractive error

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Purpose: To determine the factors contributing to undercorrected refractive error among Singaporean Malays aged 40 and above and to compare the knowledge on refractive error and effect of undercorrected refractive error among Singaporean Malays.

Methods: Subjects in this study are part of the ongoing randomised, population based study on Singaporean Malays aged 40 and above (Singapore Malay Eye Study, SIMES). All subjects who presented for SIMES from December 2005 to present date with refractive errors underwent a full optometric and ophthalmology assess (as part of SIMES) and were given a questionnaire to assess their knowledge on refractive errors, effect of refractive error on their daily activities and factors contributing to their undercorrected refractive error.

Results: From December 2005 to February 2006, 290 subjects were included in this study. Of these 290 subjects, 56% had undercorrected refractive errors. 71 (43.6%) of subjects with undercorrected refractive error do not know that they have refractive error. 102 (62.6%) of the 163 subjects with undercorrected refractive error wears glasses, but only 40.8% of them visit an eye care practitioner more than once in 5 years. The main reasons why Singaporean Malays with undercorrected refractive error do not correct their refractive error include cost of seeing an eye care professional and because they feel that they do not need perfect vision for their daily activities.

Conclusion: A high proportion of Singaporean Malays have undercorrected refractive error. Analysing the contributing factors for this present situation will provide information on how to reduce the rate of undercorrected refractive errors among Singaporean Malays.

S045

The relationship between refractive error and eyeball shape in humans

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Purpose: To determine the relationship between refractive error and the shape of the human eyeball.

Methods: Sixty-nine adult subjects, with refractive errors ranging from +3.50 D to −16.00 D, participated in this study. Ultrasound imaging of the eyeball was done using the Philips HDI 5000 ultrasound system. An ellipse was fitted to the ultrasound image of the eyeball and the p-value calculated for that ellipse.

Results: There was a weak but significant relationship between refractive error and eyeball shape ($r = 0.45$, $p < 0.05$). The more myopic the eye, the greater the tendency for the shape to be prolate. Hyperopic eyes tended to be oblate in shape.

Conclusion: In common with previous observations, the human myopic eye is associated with a prolate shape. However, it is unclear whether the eyeball shape is a 'cause or effect' of the myopia present. Longitudinal studies in pre-myopic children are necessary to explore the association between eyeball shape and refractive development further.

S046

The utility of 3-D modelling of human myopia based on magnetic resonance imaging

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Purpose: To demonstrate the application and utility of our recently reported technique that has characterised non-invasively the 3-dimensional shape of the complete human eye using Magnetic Resonance Imaging (MRI).

Methods: The technique involves the acquisition of a T2-weighted MRI (voxel thickness $0.5 \times 0.5 \times 1.0$ mm), which is optimised to reveal the fluid-filled chambers of the eye. Automatic segmentation and meshing algorithms generate a 3-D surface model, which can be segmented into morphological parameters such as longitudinal and Pythagorean distances from the posterior corneal pole, transverse distances from points along the optical axis, ocular volumes and deviations from mean posterior globe sphericity. Similar parameters can also be determined for the crystalline lens. Using 3-D MRI eye models of data from 14 eyes of seven individuals exhibiting a range of ametropia/anisometropia, the spatial accuracy of the technique was assessed by comparing the MRI-derived axial lengths with those using partial coherent interferometry (PCI). Repeatability was determined from 10 separate repeat sessions on an individual subject.

Results: Good concordance was found between MRI and PCI measures of axial length with the former showing a +0.41 m unbiased mean difference compared to PCI ($y = 1.04 \times -0.008$; $r = 0.98$). Repeatability was 23.78 ± 0.27 (SD) mm, which is consistent with voxel thicknesses used and equivalent to ultrasound measurement. Comparisons between 3-D images, colour-coded for a variety of morphologic features, generally confirm previous well documented structural features of the myopic eye but highlight inter-subject variation in asymmetry of ocular stretch between retinal quadrants.

Conclusion: We envisage the technique will provide structural foundations for investigations concerning (1) novel biometric parameters that may pre-dispose individuals to myopia; (2) the potential interaction between the topography of ocular stretch and retinal image shells; (3) ocular volume and intra-ocular blood flow and (4) the risk of retinal pathology in high myopia.

S047

Accommodative stimulus response curve of emmetropes and myopes

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Purpose: The study aims to compare the abilities of young adult emmetropes and myopes in responding to accommodative stimuli, as indicated by their Accommodation Stimulus Response Curves (ASRC) in a predominantly Chinese population.

Methods: Seventeen emmetropes and 33 myopes aged between 16 years and 23 years (mean, 18.6 ± 1.2) were recruited, of which 11 were progressing and 22 were non-progressing myopes. The ASRC gradients of subjects were measured using the methods of decreasing distance series (DDS), positive (PLS) and negative lens series (NLS).

Results: The ASRC is method dependent. The gradients of the curves are significantly different among three methods of measurement using single-factor ANOVA (F3.057 = 44.815, P).

Conclusion: Accommodative responses of myopes were more sluggish though there were no statistical differences in ASRC gradients between emmetropes and myopes. It is not certain if the poorer accommodative responses were a cause, or a consequence of myopia.

S048

The degree of myopia influences the effect of accommodation on intraocular pressure

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Purpose: To investigate eye size as a function of ethnicity in emmetropic, school-aged children.

Methods: Children in American primary school grades 1–8 were recruited and examined at five clinical sites (Eutaw, Alabama; Houston, Texas; Irvine, California; Orinda, California; and Tucson, Arizona). Information from each child's first visit (1997–98 or after) was used for this report. Children with cycloplegic autorefraction results between –0.25 D and +1.00 D in both principal meridians were considered emmetropic and were included in this data set. Five ethnic groups were represented in this sample: African Americans ($n = 312$), Asians ($n = 162$), Hispanics ($n = 264$), Native Americans ($n = 200$) and Whites ($n = 358$). Refractive error, corneal curvature, crystalline lens parameters, and axial length were measured using cycloplegic autorefraction, autokeratometry, videophakometry, and A-scan ultrasonography.

Results: Corneal curvature in Native Americans was significantly flatter compared to all other ethnic groups ($p < 0.005$) while Whites had significantly steeper curvatures than both African Americans and Hispanics ($p < 0.01$). Native

Americans had longer eyes than African Americans and Whites ($p = 0.001$ and < 0.001, respectively). The eyes of Hispanic children were also longer than those of White children ($p < 0.001$). The calculated lens power of Whites was significantly higher than all other ethnic groups ($p < 0.001$).

Conclusion: Emmetropic, Hispanic children have eyes that are longer and corneas that are flatter in the horizontal meridian compared to White children. Native American emmetropic children have eyes that are longer, corneas that are flatter, and lower lens power compared to African American and White children. The eyes of Asian emmetropes were similar with respect to length, cornea curvature and lens power to both African American and White emmetropic children.

S049

Visual performance of LASIK patients under photopic and mesopic conditions

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Purpose: The study aimed to compare the visual performance of LASIK eyes measured using the high contrast logMAR letter charts under photopic and mesopic conditions.

Methods: We recruited 46 subjects (35 ± 8 years of age) undergoing LASIK procedures. The best spectacle corrected visual acuity (BSCVA) of each subject was measured using the high contrast ETDRS logMAR chart under photopic and mesopic conditions at three visits: pre-operative (Pre), post-operative 1 month (Post1) and 3 months (Post3). The differences in logMAR scores for the right eyes only were analysed for the Pre-Post1 (n = 46), Pre-Post3 (n = 18) and Post1-Post3 (n = 16) comparisons.

Results: The logMAR scores of subjects decreased at the postoperative 1-month visit than pre-operatively, but improvement in visual performance was seen at the postoperative 3-month visit. Changes were more evident under mesopic than photopic conditions. The means and standard errors of the differences in logMAR scores for the Pre-Post3 (0.097 ± 0.020) were slightly larger than those of the Pre-Post1 (–0.067 ± 0.019) and Post1-Post3 (0.031 ± 0.012) comparisons. Visual performance of the subjects was statistically significant for the three comparisons under mesopic condition only.

Conclusion: High contrast logMAR chart performed under mesopic condition provided a more reliable representation of postoperative visual outcomes of LASIK eyes than visual acuity measured under photopic condition. This vision test should be routinely performed to gauge the success of the LASIK surgery.

S050

The effect of laser panretinal photocoagulation on refractive development in the myopic post-weaned pig: relevance to the myopia of ROP

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Purpose: It is known that premature babies and particularly those suffering from the retinopathy of prematurity (ROP) tend to be myopic, the severity of the myopia correlating with the severity of the ROP.

Methods: It has been suggested that experimental myopia induced in animals by visual deprivation in early life may be mediated by abnormal cell signalling in the retina in response to an inappropriate retinal image. Laser treatment in ROP (and to a lesser extent trans-scleral cryotherapy) may not only control the clinical manifestations of ROP but also additionally result in a reduction in the severity of the myopia associated with this condition. This reduction in the myopia might be mediated by the effects of laser on retinal cell signalling or brought about by control of the ROP itself. We have investigated the pattern of ocular and refractive development in spontaneously myopic post weaned pigs from the age of two weeks to 36 weeks.

Results: In a group of six such animals one eye at random received near confluent laser photocoagulation to the pre-equatorial retina. During the subsequent follow up period there was no difference in the rate of eye growth or of refraction between the treated and untreated eyes.

Conclusion: It is suggested that the reduction of myopia in ROP eyes treated with laser to the peripheral poorly vascularised retina is mediated by destruction of hypoxic retina and that retinal hypoxia with its known upregulation of growth factors may be an etiological factor in this type of myopia.

S051

Ocular measurements from birth to young adulthood of rhesus monkeys

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Purpose: To examine the relationship of the ocular components to changes in refractive error from birth through adolescence in rhesus monkeys (*Macaca mulatta*). We have reported on the changes in refraction during emmetropisation. The present report is a more detailed analysis that includes changes in anterior chamber depth (ACD), lens thickness (LT), and vitreous chamber depth (VCD).

Methods: Measurements were obtained from 237 monkeys, whose ages ranged from birth to 5 years. Examinations included cycloplegic retinoscopy (RE), A-scan ultrasonography (AL), and keratometry (CP). LT, ACD and VCD were measured from the echograms. The intercorrelations of these variables were analysed, as well as their association with age and sex.

Results: Mean RE at birth is +6 D, and asymptotes at +2 D, around 1.5 years of age. LT at birth ranges from 3 to 3.6 mm,

with little change up to 5 years. At birth, AL is 13.2 mm and CP is 58 D; ACD ranges from 1.8 to 3.0 and VCD ranges from 7.5 to 9.3 mm. By 5 years, AL is 19.5 mm and CP is 51 D; ACD ranges from 3.3 to 3.6 mm, and VCD ranges from 11.5 to 13 mm. Changes in VCD were correlated with AL ($r = 0.92$, $p < 0.05$), and ACD ($r = 0.89$, $p < 0.05$). Changes in RE were not highly correlated with changes in AL ($r = -0.39$), but were correlated with changes in ACD ($r = -0.66$, $p < 0.05$). With the exception of RE, males tended to have greater measurements than females.

Conclusion: From birth through adolescence, the ocular components of the rhesus monkey change in a manner similar to that of humans. These results provide a critical database for studies of normal and abnormal ocular development in primates.

S052

Peripheral refraction in normal infant rhesus monkeys

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Purpose: To better understand the influence of peripheral refractive errors on ocular growth, we examined the peripheral refractions in monkeys during the rapid period of emmetropisation.

Methods: Cross-sectional data on peripheral refractive errors were obtained from 34 normal rhesus monkeys at about 3 weeks of age. Longitudinal data were obtained at 2–3 week intervals from two normal monkeys and the untreated control eyes of 13 monkeys in which the fellow eye had undergone a retinal laser procedure. Refractive errors were measured by retinoscopy (1% tropicamide) along the pupillary axis and at eccentricities of 15, 30, and 45 degrees along the horizontal meridian in both the temporal and nasal visual fields.

Results: At 3 weeks of age, the mean spherical equivalent refractive error (SERE) along the pupillary axis was $+3.78 \pm 1.38$ D. The average SEREs in the temporal field were not significantly different from the central refractive error; however, at all eccentricities the SEREs in the nasal field were less hyperopic. The magnitude of the relative peripheral myopia increased as the degree of central hyperopia increased. In contrast, astigmatism increased symmetrically to about 2.0 D at 45-degree eccentricities in both the temporal and nasal fields. With age, the average amount of peripheral astigmatism decreased and the peripheral SEREs became more symmetrical with both the nasal and temporal hemifields exhibiting slightly less hyperopic SEREs (mean $= +0.48 \pm 0.90$ D at 45 deg) than the central retina.

Conclusions: The SERE varies as a function of eccentricity in infant monkeys and, as in humans; the pattern of peripheral refraction varies with central refractive error. Given the symmetrical nature of the astigmatic errors, the nasal-temporal differences in SEREs are likely to reflect asymmetries in the posterior globe. These asymmetries disappear during emmetropisation.

S053

What is the best dioptric value of near addition lenses?

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Purpose: The purpose of this study was to determine the best dioptric value of near addition lenses, which can create the least error in accommodative and vergence responses.

Methods: We evaluated accommodative response, phoria, and fixation disparity through multiple addition lenses (0 D, +0.50 D, +1.00 D, +1.50 D, and +2.00 D) at three working distances (33 cm, 40 cm, and 50 cm) for 30 young adults (eight emmetropic, 20 myopic, and two hyperopic). Fixation disparity was measured with a Sheedy disparometer, phoria was determined by alternating cover test with prism neutralisation, and accommodative response was determined with a Canon R-1 infrared optometer under binocular viewing condition. For each subject, the phoria and accommodative response data at three working distances measured without addition lenses were used to compute the subject's response AC/A ratio.

Results: For all three working distances, fixation disparity and phoria increased in the exo direction as plus lens power increased. We fitted the data with regression lines to determine the ideal add powers. At viewing distances of 33 cm, 40 cm, and 50 cm, error of accommodative response was zero through +1.28 D, +1.04 D and +0.92 D; and near phoria was 3 PD exophoria through +0.20 D, +0.35 D and +0.58 D, respectively. These addition lenses caused fixation disparities that ranged between –2.28 and –5.60 min of arc. In addition, we found that the correlations between the AC/A ratio and the phoria shift caused by the addition lenses at three distances were significant (all $p < 0.05$).

Conclusion: The results corresponded with theoretical expectation that subjects with high AC/A ratio showed greater exophoric shifts than the subjects with low AC/A ratio when both viewed through the same power addition lens. When the effects of plus lenses on the accommodative and vergence systems were both considered, the best dioptric power of the near addition lens was in a range of +0.20 D and +1.28 D.

S058

Measurement of peripheral retinal thickness using optical coherence tomography among Hong Kong Chinese myopes

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Purpose: To measure peripheral retinal thickness using optical coherence tomography (OCT) and study the relationship with macular thickness, refractive error and axial length.

Methods: In our pilot study, twenty myopic subjects with normal visual acuity and ocular health underwent examina-

tion of one randomly selected eye. Refractive status was determined by autorefraction with open-field autorefractor with pupil dilation. Axial lengths were measured by IOL Master. Retinal thickness measurements were performed using Stratus OCT (model 3000, software ver.4.0; Carl Zeiss Meditec, Dublin, CA), the subjects seated in a chin rest and the machine aligned to the eye being tested, while contra lateral eye were occluded. The OCT lens was adjusted for the subjects' refractive error. The subjects were instructed to fixate an external target for peripheral retina scan, in order to position the desired retinal location (i.e. nasal and temporal peripheral retina approximately 45 degree (~13.5 mm) from fovea) within view of the examiner real-time. Measurements were repeated by a single operator.

Results: The mean spherical equivalent error of the eyes was −4.11 ± 2.15 D. The mean axial length was 25.50 ± 0.79 mm. The measurement on peripheral retina was found repeatable using analysis suggested by Bland and Altman (1986). Ninety-five per cent of the values (19 of 20) fell within 1.96 standard deviations of the mean. The averaged nasal and temporal retinal thickness was 149 ± 15 μm and 127 ± 14 μm respectively. Nasal retina was thicker than temporal retina (paired *t*-test, $p < 0.000$). The preliminary results showed peripheral retinal thickness did not vary with myopia, axial length and averaged macular thickness.

Conclusion: The measurement of approximately 45-degree nasal and temporal peripheral retina is repeatable. Further investigation should be performed on the association between the peripheral retinal thickness and axial length.

Poster Papers

P043

Accommodative lag and near heterophoria of Chinese myopic and emmetropic children

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Purpose: To investigate accommodative lag and near heterophoria for Chinese myopic and emmetropic children to obtain information for effectively slowing down myopia progression.

Methods: A total of 280 subjects (aged 5–13) were enrolled with myopia SE from −0.37 to −5.25 D (–2.01 D ± 0.95) (best corrected VA ≥ 20/25). Accommodative lag was measured with MEM dynamic retinoscopy at 33 cm, and near phoria was measured with Cover test, Howell test (HT) and Modified Thorington test (MTT).

Results: Mean lags of myopic and emmetropic children were 0.97D (±0.43) and 0.82 D (±0.54) for right eye. 23.2% of myopic children with myopic parents shows higher lag than the others ($F = 3.53$, $p < 0.05$). With full correction, higher myopes tended to have larger accommodation lag ($p < 0.01$). The mean near phoria for 4.95, while higher ±Δ4.55 and –1.75 ± Δmyopic children in HT and MTT were –0.94, 3.94) was found for emmetropes. For HT, ±Δ3.07 and –3.34 ± Δvalues (–2.23 percentages of near esophoria for myopic and emmetropic children were 28.0% and 13.3%. While a similar distribution (22.8% and 6.7% esophoria) was found for MTT. And the percentages of near exophoria for myopic and emmetropic children were 41.6% and 60.0% (HT), 49.2% and 70.0% (MTT). Myopic children with near orthophoria or esophoria showed larger accommodative lags than those with near exophoria ($F = 7.97$, $p < 0.025$ for HT; $F = 3.53$, $p < 0.05$ for MTT).

Conclusion: With full distance correction, the Chinese myopic children tend to have a larger mean lag of accommodation than emmetropes, especially for those with myopic parents. Higher percentage of esophoria was found in the myopes than emmetropes. The high proportion of children with large accommodative lag may be a factor contributing to the high prevalence of myopia in Chinese school children. It is significant to ask if both parents are myopic and to measure near phoria for myopic children to prescribe PALs with optimal chances of success.

P044

Peripheral refractive changes with accommodation in emmetropic and myopic eyes

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Purpose: To assess the effect of changes in accommodative demand on peripheral refraction in emmetropic (EMM) and myopic (MYO) human eyes.

Methods: Twenty-one EMMs and 19 MYOs aged 20–30 years (mean ± SD: 22.7 ± 2.8 years) monocularly viewed a stationary high contrast (85%) Maltese cross at 0, 1, 2 and 3 D of accommodative demand and at 0, 10, 20 and 30 degrees field angle (nasal and temporal) through a +5 D Badal optical system. Static recordings of the accommodation response were obtained for each accommodative level, at each field angle, with an open-view infrared optometer (SRW-5000, Shin-Nippon).

Results: Relative Peripheral Refractive Error (RPRE) values varied systematically with field angle in both groups ($p < 0.0005$). Myopes exhibited a relative hyperopic shift with increasing field angle ($p < 0.05$) while the EMM group showed a relative myopic shift ($p < 0.05$). Accommodative demand produced a significant change in RPRE at 30 degrees temporally in the EMMs only ($p = 0.02$). For both EMMs and MYOs, astigmatism increased with field angle, with a greater effect for temporal field angles ($p < 0.0005$). Accommodation induced a

significant and systematic increase in relative cylinder power at 30 degrees temporally in both the EMM ($p = 0.02$) and MYO ($p = 0.01$). This effect was not evident in the nasal periphery.
Conclusion: The negative shift in RPRE values with increasing field angle found in EMMs indicates an oblate retinal contour in the horizontal plane. The relative hyperopic shift found in MYOs as field angle is increased indicates a prolate (i.e. flattening) retinal contour, with a greater degree of shape change in the temporal retina. Change in peripheral astigmatism with accommodation is asymmetrical in both EMMs and MYOs. The systematic change seen in RPRE with accommodation in the temporal retina of EMMs may facilitate a feedback mechanism absent in MYO eyes.

P045

Accommodation response for an accommodative 2-D step change of myopes and emmetropes

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Purpose: The present study was done to distinguish the static and dynamic accommodation responses in emmetropes and myopes for binocular viewing with different fixation periods.
Methods: Closed-loop accommodation responses were measured in a group of emmetropes ($n = 23$, mean age 20.9 ± 1.0 years) and late-onset myopes ($n = 20$, mean age 20.6 ± 1.5 years) by use of a Grand-Seiko WV5100K autorefractor. The subjects viewed a near fixation target at 40 cm. A variation in fixation period (10 s and 60 s) before an accommodative 2-D step change (–2 D to –4 D) was used to stimulate the accommodation.
Results: Group results of accommodative response times showed that late onset myopes had significantly longer response times compared to emmetropes irrespective of duration of fixation. The accommodation responses of the late onset myopes were significantly lower than that of emmetropes for both fixation periods.
Conclusion: Late-onset myopes show a longer response time after a near vision task. The results demonstrate a slower blur appreciation under dynamic conditions during near work.

P046

Open-view binocular shack-hartmann wavefront sensor

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Purpose: We have developed an open-view binocular Shack Hartmann wavefront sensor to measure accommodation, vergence, and pupil size of both eyes.
Methods: Two optical channels, comprised of Shack-Hartmann wavefront sensors and anterior imaging cameras, were laterally aligned to both eyes. A dichroic mirror reflected near infrared light between the eye and the measuring instrument while visible light from an object passed thorough the mirror to the eye. We used one million pixel CCD cameras and three fast PCs to grab images from the sensors and analyse data. We confirmed the accuracy and precision of accommodative measurements using model eyes and human eyes. We also measured accommodative response of ten eyes in five subjects to quickly turning on and off two stimuli of 60 cm distance from the eye (1.7 diopters) on a LCD monitor and 80 cm distance (1.2 diopters) on the other monitor.
Results: Accuracy of accommodation was found to be 0.03 diopters when we measured the model eyes. The precision was 0.16 diopters for human eyes. With a combination of high grade CCDs and powerful PCs, we achieved 20 accommodation measurements per second for each eye. Variation of accommodation to the stimuli was consistent between both eyes for all subjects. We found in one of subjects that variation of spherical aberration correlated with that of accommodation. But for the other subjects, variation of spherical aberration didn't correlate with that of accommodation. The variation of the spherical aberration was sometimes large for those subjects. We speculated that tear film dynamics and the prismatic vergence of the subjects' eyes may influence on the variation of aberration.
Conclusion: We confirmed the accuracy of the open-view binocular Shack-Hartmann wavefront sensor. We believe it will be a useful instrument for the investigation of the relationship between accommodation and monochromatic aberrations.

P047

The relationship between corneal shape, ocular aberrations and retinal curvature in hyperopia, myopia and emmetropia

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Purpose: Research examining differences in ocular components between refractive groups has mostly been confined to assessing parameters along the visual axis. However, recent work has suggested that off axis image quality may have a role in determining ocular shape and refractive error. The aim of the experiment was to determine whether any relationship exists between corneal asphericity, ocular aberrations and retinal shape in hyperopia, myopia and emmetropia.
Methods: 20 hyperopic, 20 myopic and 20 emmetropic subjects participated with informed consent in the study. All groups were matched for age and all subjects had VA of 0.0 logMAR or better. Refractive error ranged from –7.25 D to +6.50 D spherical equivalent and cylindrical error was restricted to ≤ 2.00 DC. Corneal topography was measured with the Orbscan, and whole eye aberration was assessed with the Zywave.

Retinal shape was measured using the IOL Master at 5 degree intervals to 40 degrees eccentricity temporally and 35 degrees nasally along the horizontal meridian, while the subjects' pupils were dilated using 2.5% phenylephrine.

Results: The hyperopic group had a significantly greater mean Z (4,0) coefficient (spherical aberration, $p = 0.01$) and Z (3,1)/ Z (3,–1) coefficients (trefoil, p-0.01) than the myopic group. There was no significant difference in whole eye aberration between the emmetropic group and either the hyperopic or myopic groups. Corneal asphericity was significantly less negative in the hyperopic group compared to the myopic group ($p = 0.05$). Retinal curvature tended to be more spherical in the hyperopic and emmetropic groups compared to the myopic group, although this difference was not significant and a high level of inter-subject variability was evident.

Conclusion: Monochromatic aberrations, corneal shape and retinal curvature show evidence of systematic variations with refractive error. This may imply some form of coordinated eye growth, although it is not possible to say whether this is passive or actively controlled.

P048

Blur adaptation effects on accommodation in emmetropes and myopes

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Purpose: To investigate the effects of two levels of blur adaptation on visual resolution and steady-state accommodation responses in myopic and emmetropic subjects.

Methods: Eleven emmetropes (mean Rx $+0.01 \pm 0.31$ D) and eleven early onset myopes (mean spherical Rx -4.44 ± 1.64 D) fixated at distance for 45 min. All subjects were optimally corrected (thin soft contact lenses used for myopes), with the addition of either; (a) Plano, (b) $+1$ DS or (c) $+3$ DS lenses and monocular LogMAR visual acuity (VA) was recorded at regular intervals. Each subject performed all three regimens, with sessions separated by one week. The SRW-5000 autorefractor was used to record distance refraction, pupil size and accommodative response to stimuli of 0–4.5 D both pre- and post-blur adaptation.

Results: Blur adaptation was found to have no effect on pupil size or distance refraction, regardless of the blur magnitude. Adaptation to $+1$ DS defocus yielded an improvement in VA of 0.156 ± 0.067 and 0.167 ± 0.108 LogMAR units in the emmetropes and myopes respectively. An improvement in VA of 0.196 ± 0.175 in the emmetropes and 0.258 ± 0.166 LogMAR units in the myopes was observed following exposure to $+3$ DS defocus. Overall, both $+1$ DS and $+3$ DS adaptation levels produced significant changes in acuity.

Conclusion: Greater magnitudes of blur adaptation produce greater improvements in visual acuity. Blur adaptation increased the visual resolution, but failed to affect the ARSC gradient or steady state responses to an accommodative stimulus.

P049

Blur adaptation effects on blur sensitivity

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Purpose: To investigate the effects of blur adaptation on the blur detection and discrimination thresholds. The adaptation period was designed to mimic uncorrected myopic distance vision.

Methods: Eight subjects (mean age 23.5 ± 5.32 years) underwent a monocular cycloplegic refraction. A bipartite target was viewed via a Badal lens system, with a 4 mm artificial pupil and the optimal refractive correction. A method of adjustment was performed by altering the moveable half of the target to determine the point of first detectable distal blur. The target position was reset, $+1$ DS was then added to the refraction and a method of adjustment was used again to detect a just noticeable difference (JND) in blur perception. Each threshold measurement was repeated six times. Blur adaptation was induced over a 30-min period of monocular distance fixation with full correction and $+1$ DS addition. Following the adaptation period, the points of first detectable blur and JND were rechecked.

Results: Initially, the mean blur detection threshold was $+0.18 \pm 0.09$ D. Once $+1$ DS blur was added to the refraction, the blur sensitivity increased and the mean JND threshold fell to $+0.12 \pm 0.03$ D. The JND threshold was significantly less than the blur detection threshold ($p = 0.04$). A significant improvement in LogMAR visual acuity (VA) occurred during the 30 min blur adaptation phase (mean improvement: 0.095 LogMAR units). Following adaptation, the blur detection threshold had increased to $+0.27 \pm 0.13$ D ($p < 0.01$), and JND threshold had increased to $+0.16 \pm 0.03$ D ($p < 0.01$). Adaptation to $+1$ DS blur produced a mean reduction in blur sensitivity of 47.8% and 35.7% for blur detection and JND respectively.

Conclusion: Blur adaptation causes a significant increase in the blur detection and discrimination thresholds, in addition to the well-documented improvement in high contrast visual acuity.

P050

A study into dynamic refraction and accommodation in myopia

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Purpose: The pathology of the accommodation apparatus is the subject of continuous interest. Weakened accommodation is known to be one of the major pathogenetic factors of myopia development (E. Avetisov, 1986). In this connection, it is especially interesting to investigate the dynamics of accommodation not only by direct methods, e.g. using an accomod-

ometer/accommodograph Nidek-2000 (M. Kolotov, 1999), but also indirect methods that allow an assessment of the working efficiency of the ciliary muscle by temporal changes of the objective refraction.

Methods: We have examined 20 patients aged 10–40 with myopia (–0.75 to –7.75 D) and 10 subjects (control group) without myopia (±0.5 D). Irrespective of refraction type, all patients had complaints connected with prolonged computer work (6 h per day or more). The follow-up consisted of measuring visual acuity and refraction, accommodometry (determination of absolute accommodation volume, pomatum proximum and punctum remotum points of clear vision) using a Biomass accommodometer; automatic pneumotonometry (Reichert xpert NCT pneumotonometer); dynamic refractometry using a PLUSOPTIX [CR03] device (PlusoptiX AG, Germany).

Results: A study into dynamic refraction and accommodation in patients with myopia and emmetropia who had astenopic complaints showed that the most pronounced fluctuations of the objective refraction at different distances from the eye to the object presented to it are noted in low myopia and emmetropia. The maximum accommodation strain is observed at the distance of 30 cm. The statistically significant difference of the objective and the subjective refraction from gaze fixation at a maximum distance (in this experiment, 2.5 m) observed in the group of patients with emmetropic refraction combined with astenopic complaints can be estimated as an increase of accommodation tonus. The difference in the levels of IOP in the both groups, which was maximal in high myopia and minimal in the group of emmetropes, testifies to changes in biomechanical properties of eye tissues, size and shape of the eyeball than on the real increase of IOP in myopia.

Conclusion: The obtained data may be viewed as an additional validation for the need to rehabilitate subjects engaged in intense visual work if they have asthenopic complaints. Special attention should be given to patients that have low myopia or emmetropia.

P051

The degree of myopia influences the effect of accommodation on intraocular pressure

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Purpose: To examine the effect of the degree of myopia and associated ocular biometry on the significant reduction in IOP for intermediate levels of accommodation previously reported (ARVO 2006, e-abstract 5859).

Methods: A modified, high resolution (0.1 mmHg) non-contact tonometer (Pulsair Keeler, UK) was coupled with a finger pulse-transducer and a LabView Acquisition Program (National Instruments) to obtain five IOP measures synchronised with the middle of the cardiac cycle in the RE while the LE (rendered functionally emmetropic) fixated a zero (low), 1.50 (intermediate) and 4 D (high) accommodative stimuli for 3 min ($n = 50$). A metronome was used to obtain a fixed pace respiratory cycle at 15 breaths/min. Accommodation responses were simultaneously sampled at 1 second intervals with the monocular Flexible-Ref FR-5000 (Grand Seiko Co, Ltd, Japan) open-view autorefractor. Ocular biometry measures comprised of anterior chamber depth (ACD), axial length (AL) (Zeiss IOL Master, Carl Zeiss Meditec) and ocular volume (OVol) (derived from 3-D MRI data).

Results: Mean ± SD accommodation response levels (D) and corresponding IOP (mmHg) measures to zero, 1.50 and 4D accommodation stimuli levels were respectively, –0.16 ± 0.34, 14.09 ± 2.36; 1.75 ± 0.23, 13.50 ± 2.68 and 4.15 ± 0.21, 14.06 ± 2.65. Consistent with our previous report, only 1.69 mmHg between low and intermediate ± the reduction in IOP of 0.59 levels of accommodation was found to be significant ($p < 0.016$). The larger mixed sample allowed comparisons between emmetropic ($n = 21$) and myopic ($n = 28$) groups and within the myopic group. The former was insignificant ($p = 0.95$) whereas a median split (–3.29 D) of the latter demonstrated significant differences in IOP responses on accommodation ($p = 0.005$). In contrast, median splits for ACD, AL and OVol within the myopic group failed to show significant effects.

Conclusion: The degree of myopia influences IOP change on accommodation, however there is no single structural correlates that accounts for the relationship. The potential for interaction between biometric components and intraocular blood flow is currently being examined.

P052

Improvement of accommodation capacity and temporal contrast sensitivity of the eye to colour stimuli as a result of functional treatment of progressive myopia in children and adolescents

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Purpose: Critical flicker-fusion frequency (CFF) is known to characterise temporal contrast sensitivity of the eye. The purpose is to study the accommodation parameters and CFF in children with progressive myopia and to evaluate changes of these parameters after functional treatment.

Methods: A total of 63 patients aged 9–18 with accommodation disorders and myopia from –1.00 to –8.75 D were examined before and after combined functional treatment, including visual tests, autorefractometry, measurement of nearest and farthest points of clear vision, absolute accommodation volume (AAV), and CFF in response to colour stimuli. Combined treatment included cardioimpulse infrasound pneumatic massages following 2% phenylephrine solution

instillations, and low-energy transscleral laser stimulation of the ciliary muscle using Macdel-09.

Results: A significant decrease of AAV against age norm was observed in all patients before treatment. Also, CFF (period/s) showed a regular decrease in children with low, moderate and high myopia, equalling 39.5 ± 1.0, 38.7 ± 0.5, 36.3 ± 0.5 for the red stimulus (normally 42.3 ± 0.5), 38.9 ± 0.9, 38.0 ± 0.8, 37.5 ± 0.9 for the blue stimulus (normally 40.3 ± 0.4) and 41.9 ± 1.1, 40.3 ± 0.7, 38.8 ± 0.9 for the green stimulus (normally 43.3 ± 0.6), respectively. The motor-sensory parameters showed strong correlation, which was substantiated by similar changes after functional treatment. AAV showed a drastic increase to 8.9 ± 0.5 D in low myopia, 6.6 ± 0.5 in moderate myopia and 6.3 ± 0.6 D in high myopia. CFF values averagely increased for all stimuli by 9.3% in low myopia, by 8.8% in moderate myopia and by 9% in high myopia.

Conclusion: This kind of treatment boosts the capacity of the ciliary muscle, probably due to improved blood supply of the muscle and internal shells, and has a favourable effect on the discriminating facilities of the retina. Thus, CFF reflects the state of motor-sensory functions of the eye. Changes of the parameter after treatment may serve as a criterion of its efficiency.

P053

Objective aberration stimulus response of the human myopic and emmetropic eye

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Purpose: To compare the stimulus response of objectively measured aberrations of the human eye in emmetropes and myopes up to the 8th Zernike order over a 12.0 D range.

Methods: Six emmetropes (EMM; average mean spherical equivalent -0.17 ± 0.2 D, average age 23.8 ± 4.9 years), six early onset myopes (EOM; average age of onset 10.5 ± 1.3 years; MSE -4.29 ± 1.17D, age 20.5 ± 0.5 years) and six late onset myopes (LOM; onset 14.9 ± 1.7 years; MSE -3.05 ± 1.56D, age 21.0 ± 1.7 years) had their ocular aberrations measured with a modified Topcon KR9000-PW over a 4-mm undilated pupil. The aberrometer had an internal Maltese cross fixation target that could be moved along the visual axis within a Badal optical system. Subjects viewed the target at 0.0 D accommodative demand before and after each step change, each dioptric distance between 1.0 and 12.0 D in 1.0 D steps viewed in random order.

Results: Defocus increased linearly with increasing accommodative demand ($p < 0.0005$), with no difference between refractive groups ($p = 0.59$). Spherical aberrations became more negative between 0 and 9 D of accommodative demand ($p < 0.0005$) in all refractive groups. Conversely, a positive inflection in spherical aberration occurred beyond 9 D of accommodative demand ($p < 0.01$) with LOMs exhibiting the greatest positive shift, however, this was not significant ($p = 0.15$). Between 0 and 9 D there was no significant difference in horizontal coma ($p = 0.40$), however, beyond 9 D there is a negative shift in horizontal coma ($p = 0.005$) with LOMs exhibiting the greatest shift, however, again this was not significant ($p = 0.56$). Vertical coma increased with accommodative demand ($p < 0.05$), with no difference between refractive groups ($p = 0.48$).

Conclusion: Despite steadily increasing lag of accommodation over the 12.0 D focusing range, spherical aberrations and horizontal coma change profile with higher levels of accommodative demand. No clear differences between myopes and emmetropes were evident.

P054

Depth of objective aberration focus of the human myopic and emmetropic eye

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Purpose: To compare the objective depth of focus of the human eye in emmetropes and myopes assessing aberrations up to the 8th Zernike order.

Methods: Six emmetropes (EMM; average mean spherical equivalent -0.17 ± 0.2 D, average age 23.8 ± 4.9 years), six early onset myopes (EOM; average age of onset 10.5 ± 1.3 years; MSE -4.29 ± 1.17 D, age 20.5 ± 0.5 years) and six late onset myopes (LOM; onset 14.9 ± 1.7 years; MSE -3.05 ± 1.56 D, age 21.0 ± 1.7 years) had their ocular aberrations measured with a modified Topcon KR9000-PW over a 4-mm undilated pupil. The aberrometer had an internal Maltese cross fixation target that could be moved along the visual axis within a Badal optical system. Changes in aberrations were determined when each individual's Zernike coefficients changed by more than the 95% confidence interval from baselines of 0.0D, 1.5 D and 3.0 D with ± 0.1 D steps over ± 0.9 D.

Results: Depth of focus varied in defocus term with baseline accommodative demand ($F = 5.56$, $p < 0.01$), but not with subject's refractive error ($F = 0.30$, $p = 0.60$) or direction of change in demand ($F = 1.67$, $p = 0.22$). Spherical aberration, and horizontal and vertical coma did not alter between refractive groups and baseline or direction of change in accommodative demand ($p > 0.05$). Confidence intervals varied in defocus term with refractive group (being larger in EMM; $F = 6.06$, $p = 0.02$), but not with baseline accommodative demand ($F = 1.11$, $p = 0.35$) or direction of change in demand ($F = 0.03$, $p = 0.86$). Spherical aberration, and horizontal and vertical coma confidence intervals did not alter between refractive groups and baseline or direction of change in accommodative demand ($p > 0.05$).

Conclusion: Myopia and its onset do not alter objective depth of focus, although this is greater at optical infinity than at

closer distances. Spherical aberration and coma are relatively tolerant to changes in accommodative demand.

P055

Contrast detection in noise: a novel approach to investigate neural and optical loss in myopes

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Purpose: Our previous study has shown myopes are less affected by negative defocus compared to positive defocus for gratings of low-medium spatial frequencies. Emmetropes, on the other hand, show similar loss with positive and negative defocus. We investigated whether the asymmetry shown by myopes is mainly due to optical or neural factors, or both. Measurement of contrast in the presence of added visual noise allows any contrast loss to be attributed to either optical factors, neural factors or both. These are measured by means of equivalent noise levels and sampling efficiencies respectively, two parameters that are derived from contrast sensitivity measurements in noise.

Methods: Contrast thresholds were measured in four different levels of noise in a group of myopes and emmetropes for gratings of 3 c/deg. Measurements were obtained under cycloplegia with defocusing lenses of ± 0.00 D, ± 0.50 D and ± 1.00 D in optimally corrected myopes and emmetropes.

Results: In the absence of noise, there was no significant difference in contrast thresholds between myopes and emmetropes. Measuring contrast threshold in the presence of noise demonstrated no difference in sampling efficiency (neural factors) between myopes and emmetropes. However, myopes showed higher levels of equivalent noise (optical factors) with $+1.00$ D defocus compared to -1.00 D defocus ($p = 0.009$). Emmetropes showed no difference in equivalent noise between positive and negative defocus.

Conclusion: The asymmetry shown with positive and negative defocus in myopes is due to optical factors. The nature of these optical factors will be discussed in the light of data obtained using a Shack-Hartmann Aberrometer.

P056

The size of the accommodation microfluctuations are spatial frequency dependent in myopes and emmetropes

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Purpose: The aim of this experiment is to determine the effect of changes in the spatial frequency of both sine and square wave gratings upon the characteristics of the accommodation microfluctuations in myopic (MYO) and emmetropic (EMM) subjects.

Methods: Twenty-six subjects (13 EMM/13 MYO) viewed a high contrast grating monocularly through a $+5$ D Badal lens. The target was placed at a stimulus vergence, which produced an accommodation response equal to the open loop level. Subjects viewed both sine and square wave gratings of spatial frequencies 0.5, 1, 2, 4, 8 and 16 cpd. MYO subjects were fully corrected using daily disposable soft contact lenses. Accommodation responses were measured continuously at a sampling rate of 52 Hz using a modified open view Shin-Nippon SRW-5000 autorefractor. Two minutes of data were recorded for each target.

Results: While viewing the sine wave targets, both MYOs and EMMs demonstrated small microfluctuations for mid spatial frequencies, which increased significantly when viewing the 0.5 cpd sine wave target (Scheffe *Post hoc*, $p < 0.05$). Increases in the size of the microfluctuations were also observed while viewing the 16 cpd target, however this was significant only for the MYO subjects (Scheffe *Post hoc*, $p < 0.02$). There was no significant variation in the mean accommodation response level with all targets ($p > 0.05$). Changing the spatial frequency of the square wave gratings had no significant effect on the magnitude of the microfluctuations ($p > 0.05$). Throughout both sine and square wave target viewing, the MYO group demonstrated significantly larger microfluctuations than the EMMs ($p < 0.001$).

Conclusion: The magnitude of the accommodation microfluctuations varied systematically with the spatial frequency of the sine wave gratings for all subjects. Accommodation microfluctuations were larger in MYOs for all sine and square wave targets and the MYOs demonstrated a larger increase in the microfluctuations when viewing the high spatial frequency target. The results suggest that the accommodation control system may use the microfluctuations to monitor the contrast gradient of the retinal image in all subjects, but the control system in MYOs may have a larger dead-space.

P057

Higher order aberrations in myopic children from different ethnical backgrounds

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Purpose: To analyse the differences of low and high order aberrations if any in a group of myopic children from four different ethnical backgrounds.

Methods: Refractive error and ocular aberrations from right eyes under cycloplegia were obtained with a S-H aberrometer in children participating in the Sydney Myopia Study. Analysis was performed on a sample of high school children (year 7, mostly aged 12 years old). Myopia was defined as $M \leq -0.50$ D. Eyes with astigmatism >1.00 D and PD < 5 mm were excluded from analysis. Ethnicity information was obtained from questionnaires. Aberrations and their variance (RMS) from 2nd through 6th order were compared between ethnical groups and their differences analysed using multiple comparisons Games-Howell, with significance set at $p < 0.05$.
Results: A total of 126 children were included in this study. Distribution by ethnical background was 27.8% Caucasians (A), 50.0% East Asians (B), 18.3% Indian/Pakistani/Sri Lankan (C) and 4.0% Middle Eastern (D). Significant differences existed for Z(2,0) and Defocus RMS between group B to groups A & D ($p < 0.05$). Of the higher order aberrations, differences between groups existed for Coma RMS (group B to A & C; $p = 0.006$), Quatrefoil RMS (groups B & D; $p = 0.008$), HO RMS (groups B & C, $p = 0.002$) and Total RMS (group B to groups A & D, $p < 0.001$).
Conclusion: In myopic children from different ethnical background, higher order aberrations seem to differ for some 3rd and 4th orders only.

P058

Monochromatic aberrations symmetry between eyes in a large sample of Australian children

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Purpose: To assess the symmetry of monochromatic aberrations between right and left eyes of children who participated in the Sydney Myopia Study.
Methods: Ocular aberrations were obtained for both eyes in two samples of children (sample 1, mostly aged 6 years old) and (sample 2, mostly aged 12 years old) using a S-H aberrometer under cycloplegia (PD > 5 mm). Eyes with astigmatism >1.00 D were excluded. Monochromatic aberrations expressed as Zernike polynomial expansion from 2nd through 6th order were analysed. Odd symmetric terms were inverted in sign in the left eyes to test for symmetry. Correlations between terms were analysed using Pearson's bivariate correlation with significance set at $p < 0.05$.
Results: A total of 3000 children (1364 sample 1; 1636 sample 2) with a mean age 6.7 ± 0.4 years, range 5.5–8.0 years (sample 1) and 12.6 ± 0.4 years, range 11.1–14.4 years (sample 2) were examined. Mean M was 1.12 ± 0.7 D (sample 1) children and 0.54 ± 1.2 D (sample 2). Highly significant correlations ($p < 0.001$) were found in both groups for 84% (sample 1) and 76% (sample 2) of the terms. High correlations were found for Z (2,0), Z (4,0), Z (2,2) Z (3,-1), Z (3,-3). Remaining terms on the 3rd, 4th, 5th and 6th orders presented moderate to low correlations ($r < 0.5$).
Conclusion: High to moderate symmetry of aberrations patterns between eyes of children exist for terms up to the 4th order only. Fifth and 6th orders present moderate symmetry.

P059

The association of single nucleotide polymorphism in the 5'-regulatory region of the lumican gene with susceptibility to high myopia in Taiwan

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Purpose: To study the relationships between single nucleotide polymorphisms (SNPs) of lumican, decorin, and DSPG3 genes and high myopia.
Methods: One hundred and twenty adult patients with high myopia (< -10.0 D) and 137 controls to study the relationships between the decorin, lumican, and DSPG genes and high myopia. All of the subjects were free of ocular diseases other than myopia, as well as of other systemic genetic diseases. Genotyping was performed by direct sequencing after PCR amplification of chromosomal DNA. Allele frequencies were tested for Hardy-Weinberg disequilibrium. The chi square or Fisher test was conducted to investigate the genotypic and allelic distribution between the high myopia and control groups.
Results: The genotyping success rate was 100%. Univariate analysis revealed significant differences between patients and control subjects with respect to one of the SNP (rs3759223, C $\rightarrow$ T) of the lumican gene, with a p value of 0.000283. There was no significant relationship between other SNPs of lumican, decorin and DSPG genes and high myopia.
Conclusion: Our results indicate that the SNP (rs3759223), which is located in the promoter of the lumican gene, may be worth for further investigation of association with development of high myopia.

P060

Association between the polymorphisms of the myocilin (myoc) gene and high myopia in Hong Kong Chinese population

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Purpose: To study the association between genetic polymorphisms (SNPs) of the MYOC gene and high myopia in Hong

Kong Chinese population using family-based association methods.

Methods: Nuclear families (n = 191) with 756 Chinese individuals were recruited. Each family consisted of two parents and at least one high myopic child (at least −5.00 DS for both eyes). Each subject had a comprehensive ocular examination. DNA was extracted from blood samples collected from each individual for genotyping two microsatellites and six SNPs of the MYOC gene. The microsatellites (GT repeats) are located at the 5'promoter region (NGA17) and 3'untranslated region (UTR) (NGA19) of MYOC. Four of the SNPs are within exons whereas the other two SNPs are at 5'URT (rs235920) and 3'UTR (rs2421853). The results were analysed with transmission/disequilibrium test (TDT) using the FBAT software to test for association between the marker alleles and myopia.

Results: For microsatellites, five alleles (13–17 GT repeats) and six alleles (11, 12–17 GT repeats) were found for NGA17 and for NGA19, respectively. The allele with 15 GT repeats of NGA17 showed significantly reduced transmission to the myopic offspring under both additive ($Z = -2.17$, $p = 0.0298$) and dominant ($Z = -2.38$, $p = 0.0173$) genetic models in TDT analyses. The allele with 15 GT repeats of NGA19 showed significantly reduced transmission to myopic offspring under dominant models, but the allele with 13 GT repeats showed increase transmission under recessive genetic model. Significant association was also observed between rs2421853 ($p = 0.0267$) located at 3'UTR and high myopia. For the exon SNPs, their minor allele frequencies within parents are less than 5% and thus, they were not ideal for association studies and TDT analyses.

Conclusion: The data suggested that there was association between myopia and the MYOC polymorphisms at 5' promoter region and 3'UTR. These SNPs are potential candidates in altering risk for myopia and worthy of further replication and functional study.

P061

The genetic basis of myopia in dogs

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Purpose: Studying the genetics of myopia in dogs has several potential advantages over human studies e.g. large litter size, rapid breeding, known ancestry and significantly reduced environmental influences. The aim of this study was to test refractive error in a large number of related dogs in order to isolate the mode of inheritance of myopia.

Methods: Records from a large breeding colony were used to create family pedigrees. Inclusion criteria for refractive error measurement were: age (1–8 year old) and absence of ocular pathology (all dogs examined by veterinary ophthalmologist). Refractive error was measured with a Welch Allyn Suresight Autorefractor and cycloplegic retinoscopy. DNA samples (buccal cells and toe-nail samples) were taken for genetic analysis.

Results: Breeding records for 1303 dogs were used to investigate heritability using canine pedigree software. One large family of Labrador Retrievers (334 dogs, spanning four generations) with a common ancestor (stud dog with myopia) and other known members with myopia was isolated for further study. To date, 32 dogs (of 160 available) from this family have been tested: the mean sphere refractive error within this group was -0.47 ± 1.50 D. Ten of the 32 dogs were significantly myopic (at least –1.00 D) (range –1.25 to –4.29 D). To date 147 other dogs within the colony have been tested: the mean refractive error of this group was $+0.05 \pm 1.06$ D (range +3.13 to –2.92 D). Segregation analysis, to determine possible modes of inheritance of myopia, is proving difficult because several inbreeding loops exist within the selected family (coefficient of inbreeding range: 0–12.5%).

Conclusion: Although only a small number of the selected family have been tested to date, the prevalence of myopia appears to be approximately twice that reported in previous canine studies. One disadvantage of canine genetic studies is the difficulty of analysing data when inbreeding is present.

P062

Poems of myopia

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Purpose: The 'epidemic of myopia' in urban Asian communities such as Hong Kong and Singapore in the past few decades had been well documented and studied. The roles of nature and nurture in this evolution is still being intensively studied. In Singapore, being of Chinese descent and the amount of near work seem to be implicated. This study aims to trace the presence of myopia in the Chinese from a historical perspective. The prevalence of myopia in the ancient Chinese society is not known, but evidence points to its existence in the literature. How the refractive status of the Chinese literature in the past contributed to some of their most famous work is shown. The treatment of myopia in ancient China is also described.

Methods: Literature review and Internet search.

Results: There are some notable Chinese myopes in history, the majority being poets and government officials. Some of the most famous Chinese poems give insights into the refractive status of the poets. A collection of ancient Chinese spectacles exists, and folk remedies of myopia in China abound. Together these may provide clues to the history of myopia in the Chinese population.

Conclusion: The existence of myopia in the ancient Chinese population gives further circumstantial support to the well-established near-work theory of myopia.

P063

Influence of retinal image contrast on retinal gene expression in mice

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Purpose: To detect changes in retinal gene expression that occur during short periods of spatial degradation of retinal images.

Methods: Male C57BL/6 mice, aged 30 days, were treated with a diffuser for short periods of time (30 min, 4 h, $n = 3$ for each group) over one eye while the contralateral fellow eye was fitted with a clear neutral density filter with matched light attenuation (0.3 log). Animals were individually placed in the centre of a rotating drum (60 deg/sec), covered inside with a 0.1 cyc/deg vertical square wave grating. Labelled cRNA was prepared from the 12 retinas and hybridised to Affymetrix GeneChip® Mouse Genome 430 2.0 arrays with more than 39 000 characterised genes. Changes in gene expression of candidates with potential relevance were verified by semi-quantitative real-time reverse transcription polymerase chain reaction (RT-PCR), using SYBR Green I (Qiagen).

Results: Already after 30 min of retinal image degradation, significant changes were detected, with 151 genes down-regulated and 40 up-regulated in the diffuser treated eyes, relative to the ND filter-treated references. With the 4-hour treatment period, the number of regulated genes to decreased to 27 and, again, most of them were down-regulated. Among others, egr-1 and fos mRNA levels were significantly reduced after 30 min, as well as after 4 h of diffuser wear (paired *t*-test, $p < 0.05$). Some changes in gene expression were already confirmed by semi-quantitative real-time RT-PCR, showing a significant correlation between both techniques.

Conclusion: Spatial degradation of the retinal image induces a number of transcriptional changes. The candidate genes that were responsive in both the microarray analysis and subsequent real-time PCR analyses should provide further insight into the biochemical short-term changes that occur in the retina following image degradation. Since poor retinal image quality is known to induce myopia in both animal models and humans, some of the identified genes should play a role in myopia development.

P064

Variant in TIGR confers protection against myopia

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Purpose: The trabecular meshwork-induced glucocorticoid response (TIGR) gene has been identified to be associated with glaucoma. As the prevalence of glaucoma is described associated with refractive state, we aim to evaluate the association between *TIGR* and refractive error.

Methods: A community-based non-related case control association study was performed in a cohort of 696 Singaporean Chinese children, aged between 10 and 12 years from the Singapore Cohort Study of the Risk Factors of Myopia (SCORM). Five single nucleotide polymorphisms (SNPs) were genotyped after searching relevant databases in *TIGR* using the Sequenom Mass-Array genotyping platform and analysed for association with disease.

Results: Of the five markers genotyped in *TIGR*, SNP1 demonstrated evidence of association with myopia (overall Fisher's Exact $P = 0.045$). The homozygous variant *TIGR* SNP1 A/A genotype was significantly over-represented in emmetropic and hyperopic children (5.3%) compared to myopic children (2.2%) ($2x2\chi^2 = 3.92$, $P = 0.048$). The proportion of *TIGR* SNP1 A/A homozygotes was also markedly higher (10.2%) in the most hyperopic children (top ten percentile of the population) vs the rest (2.4%) (*Fexact* = 0.007).

Further analysis revealed that children homozygous for *TIGR* SNP1 A/A displayed significantly slower progression in refractive error (χ^2 for linear trend = 5.17, $P = 0.023$), as well as a lower mean progression in refractive error (Kruskal-Wallis $P = 0.047$) compared to the children carrying the C allele.

Conclusion: Our data suggests that TIGR could be involved in the protection against myopia and its progression. Modulation of the trabecular meshwork and muscle-related ciliary body mechanisms may contribute to the development and progression of myopia.

P065

Spontaneous myopia in the pig: a new model of myopia

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Purpose: To determine the refractive status and prevalence of myopia in a representative sample of a strain of pigs of reduced genetic variance.

Methods: A representative sample of a relatively inbred Yorkshire-Landrace cross strain of pigs was investigated by cycloplegic autorefraction, keratometry and ultrasound biometry. Twenty-two pigs, varying in age from 3 months to two and a half years and in weight from 21–75 kg were examined. Correlations between the measured parameters were sought.

Results: Of the 22 pigs, 15 were myopic in each eye, four were myopic in one eye and had a low hypermetropic refractive error in the other and three were hyperopic in each eye. Negative spherical errors ranged from –0.31 D to –7.70 D with a mean value of $-3.97\ D \pm 2.14$ (S.D.). A horizontal negative astigmatic error was present in all eyes (range, –0 75 to –4.13 D, mean, $-2.13\ D \pm 0.77$, median, –1.95 D). Myopia was axial, correlating with vitreous chamber length ($r = -0.598$, $p < 0.001$). There

was a significant negative correlation between vitreous chamber length and corneal power ($r = –3.96$, $p = 0.008$) and between axial length and corneal power ($r = –0.673$, $p < 0.001$). There was a significant negative correlation between body weight and corneal power ($r = -0.664$, $p < 0.001$), explaining the reduced myopia among heavier animals with larger.

Conclusion: There is a high prevalence of axial myopia among this strain of pig. The existence of a population of pigs demonstrating a high prevalence of spontaneous myopia provides an additional and new animal model of myopia that occurs without any manipulation of the visual environment.