**371 Refractive Surgery**
Tuesday, May 07, 2013 2:45 PM-4:30 PM
TCC 303 Paper Session
**Program #/Board # Range:** 3711-3717
**Organizing Section:** Cornea

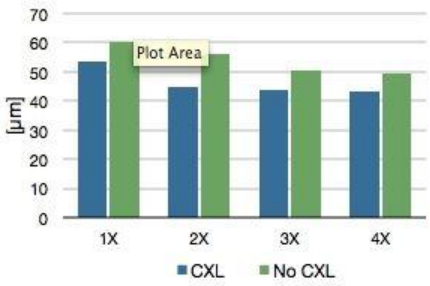
**Program Number:** 3711
**Presentation Time:** 2:45 PM - 3:00 PM
**In Vivo Confocal Microscopy Demonstrates a Profound Increase in Immune Dendritic Cells and Decrease in Corneal Nerves in Patients with Post-Refractive Surgery Keratoneuralgia**
*Yureeda Qazi[1], Shruti Aggarwal[1], Bernardo M. Cavalcanti[1], Andrea Cruzat[1], Leslie J. Wu[2], Perry Rosenthal[2], Pedram Hamrah[1,3].*
[1]Ophthalmology, Massachusetts Eye and Ear Infirmary, Boston, MA; [2]Boston Foundation for Sight, Needham, MA; [3]Immune Disease Institute, Harvard Medical School, Boston, MA.
**Purpose:** To analyze subbasal corneal nerve and immune cell changes in post-refractive surgery corneal pain patients, and their correlation to clinical signs and symptoms.
**Methods:** Laser in vivo confocal microscopy (IVCM) images of 17 patients with keratoneuralgia after refractive surgery (LASIK: n=28 eyes; PRK: n=5 eyes), and 62 controls (n=62 eyes), were analyzed retrospectively by two masked observers for subbasal nerves, and immune dendritic (DC) and inflammatory cells (IC). Keratoneuralgia was confirmed by the presence of pain with PROSE devices and lack of a response to proparacaine. Detailed history, symptom assessment (Ocular Surface Disease Index [OSDI] questionnaire) and a clinical examination (slit-lamp biomicroscopy) were obtained.
**Results:** Patients had constant pain and photophobia with sensitivity to air (94%) and chemical fumes (47%). Although minimal corneal fluorescein staining was noted, a significant loss in lengths of total subbasal nerves compared to controls (12.8±4.7 vs. 24.3±3.9 mm/mm2, $p<0.001$) and branches (4.4±2.1 vs. 13.2±3.1mm/mm2, $p<0.001$), as well as increased tortuosity (2.9±0.6 vs. 1.8±0.5, $p<0.001$) were noted. Further, a 5-fold increase in DC (102.1±92 vs. 24.6±24.9 cells/mm2, $p<0.001$) and IC densities (10.9±9.3 vs. 0.1±0.2 cells/ mm2, $p<0.001$) was seen. The decrease in total nerve length was associated with increased OSDI severity ($R= -0.7$, $p<0.001$) and tortuosity correlated with sensitivity to fumes ($r= 0.5$, $p<0.001$). Moreover, IC density correlated with OSDI severity ($R= 0.7$, $p<0.001$) and photophobia ($R= 0.8$, $p<0.001$). DC density was correlated with sensitivity to air ($R= 0.6$, $p<0.001$).
**Conclusions:** In post-refractive surgery keratoneuralgia, despite minimal findings on clinical exam, subclinical changes in subbasal nerves and increased immune and inflammatory cells are seen on IVCM. These IVCM findings correlate with symptoms. IVCM may thus provide new insights into the pathogenesis of corneal pain, which is debilitating and otherwise poorly understood.
**Commercial Relationships: Yureeda Qazi**, None; **Shruti Aggarwal**, None; **Bernardo M. Cavalcanti**, None; **Andrea Cruzat**, None; **Leslie J. Wu**, None; **Perry Rosenthal**, None; **Pedram Hamrah**, None
**Support:** NIH K08-EY020575 (PH), Research to Prevent Blindness Career Development Award (PH), MEEI Foundation

**Program Number:** 3712
**Presentation Time:** 3:00 PM - 3:15 PM
**Small Incision Lenticule Extraction (SMILE) procedure for the correction of myopia and myopic astigmatism: What we have learned after 120 eyes in 1 year**
*Arturo J. Ramirez-Miranda, Alejandro Navas, Angie De La Mota, Tito Ramirez-Luquín, Enrique O. Graue-Hernández.* Cornea and Refractive Surgery, Instituto de Oftalmologia "Conde de Valenciana", Mexico City, Mexico.
**Purpose:** To report the Visual, Refractive and clinical outcomes, stability and complications rate of 20 eyes treated with Femtosecond-only small incision lenticule extraction to correct myopic refractive errors
**Methods:** A refractive lenticule of intrastromal corneal tissue was cut utilising the VisuMax femtosecond laser system. Simultaneously an small 'pocket' incisión was created. Thereafter, the lenticule was manually dissected with a Shanzu dissector and removed from the stroma through a 3.0 to 5.2 mm incision using 0.12 forceps. Outcome measures were corrected distance visual acuity (CDVA), uncorrected distance visual acuity (UDVA), and manifest refraction during 1 year of follow-up and the complication rate . Corneal Tomography/OCT, corneal sensation and contrast sensitivity was also measured
**Results:** The study enrolled 120 eyes of 76 patients. Preoperative mean spherical equivalent was - 5.37 diopters (D) 3.27 standard deviation (SD) preoperatively and spherical equivalent +0.17 (D) 0.45 (SD) 6 months postoperatively. Refractive stability was achieved within 6 weeks. A year after the surgery, > 87% of all cases had a UDVA of 20/25 or better. The 1 year postoperative CDVA was the same as or better than the preoperative CDVA in all the eyes. Less than 5% of the eyes lost lines of CDVA. The complications rate was low (n=8).
**Conclusions:** Small Incision Lenticule Extraction (SMILE), a femto-only flapless minimally invasive technique, appears to be safe, predictable, and effective procedure to treat myopia and myopic astigmatism , with a short learning curve.
**Commercial Relationships: Arturo J. Ramirez-Miranda**, Carl Zeiss Meditec (R); **Alejandro Navas**, None; **Angie De La Mota**, None; **Tito Ramirez-Luquín**, None; **Enrique O. Graue-Hernández**, None

**Program Number:** 3713
**Presentation Time:** 3:15 PM - 3:30 PM
**Combined Small Incision Lenticule Extraction and Intrastromal Cross-linking in Forme fruste Keratoconus**
*Karla P. Lopez, Gabriela L. Pagano, Alejandro Navas, Tito Ramirez-Luquín, Arturo J. Ramirez-Miranda, Enrique O. Graue-Hernández.* Cornea and Refractive Surgery, Instituto de Oftalmologia "Conde de Valenciana", Mexico City, Mexico.
**Purpose:** To report visual, refractive and topographic outcomes of Small Incision Lenticule Extraction (SMILE) and intrastromal corneal collagen cross-linking in eyes with abnormal topography and/or forme fruste keratoconus.
**Methods:** Prospective case series of 8 eyes of 4 patients. Inclusion criteria were topographic diagnosis of forme fruste keratoconus and/or irregular corneas, CDVA ≥20/40, stable refraction of at least 1 year, patients aged ≥21 years and expected residual corneal thickness > 400 µm before performing collagen cross-linking. Patients were treated with SMILE followed by intrastromal injection of riboflavin (0.1 ml twice with a 15 minutes gap) inside the pocket. Ultraviolet A light was applied for 30 minutes in each eye. Follow-up was done at day 1, 1 week, 1-3-6 months. Study parameters were UDVA, CDVA, manifest refraction, tomographic and clinical evaluations.
**Results:** Mean age was 31.25±5.82 yrs. (range 22-36). Mean follow up was 3.00±1.31 months. Mean UDVA (LogMAR) was 1.19±0.29 preoperatively and 0.17±0.12 postoperatively ($p<0.001$). Mean pre and postoperative CDVA (LogMAR) was 0.03±0.05 and 0.12±0.10, respectively ($p=0.065$). Preoperative SE was -4.50±1.47 D (range -6.25 to -2.75) and postoperative SE was -0.30±0.72 D (range -1.25 to +1.12) ($p<0.001$). Three eyes lost 1 line of CDVA, 1 eye lost 2 lines and 1 eye lost 3 lines due to haze. All patients presented intrastromal

haze that improved during the follow-up. K1 was 42.78±0.83 D preoperatively and 39.91±2.01 D at the last follow-up visit (p=0.005). K2 was 45.81±1.85 D and 42.22±3.66 D pre and postoperatively, respectively (p=0.002). Km was 44.22±0.76 D before surgery and 41.02±2.75 at the last visit (p=0.002).
**Conclusions:** Combined SMILE and Cross-linking may be a promising treatment option in patients where conventional laser refractive surgery is contraindicated. Further follow-up and larger samples are needed. Despite the fact that the refraction was near plano, 5 eyes lost lines of CDVA due to haze.
**Commercial Relationships: Karla P. Lopez**, None; **Gabriela L. Pagano**, None; **Alejandro Navas**, None; **Tito Ramirez-Luquín**, None; **Arturo J. Ramirez-Miranda**, Carl Zeiss Meditec (R); **Enrique O. Graue-Hernández**, None

**Program Number:** 3714
**Presentation Time:** 3:30 PM - 3:45 PM
**Determination of the excimer laser ablation rate in the porcine cornea after corneal collagen cross-linking (CXL)**
*Olivier Richoz[1], Samuel Arba Mosquera[2], Thomas Magnago[2], Farhad Hafezi[1, 3].* [1]Ophthalmology, Geneva University Hospital, Geneva, Switzerland; [2]R&D, Eye Tech Solutions, Kleinostheim, Germany; [3]Ophthalmology, Doheny Eye Institute, Keck School of Medicine, Los Angeles, CA.
**Purpose:** A combination of collagen cross-linking (CXL) and customized surface ablation, performed sequentially, may be a promising means to correct for part of the irregular astigmatism in keratoconus and postoperative ectasia. Accordingly, surgeons will be confronted with patients that will present with previously cross-linked corneas requiring excimer laser ablation. Currently, the ablation rate per pulse in a cross-linked cornea is unknown, leading to potential inaccuracies in the amount of ablated tissue and postoperative result.
**Methods:** The excimer laser ablation rate of porcine corneas was analyzed using optic coherence pachymetry (OCP) ex vivo. Corneas were de-epithelialized and soaked with riboflavin 0.1% solution for 20 minutes. Riboflavin was washed off the corneal surface and corneas were cross-linked with 18 mW/cm2 for 5 minutes (CCL-365 Vario). Excimer laser ablation was performed (Schwind AMARIS 750S) to a total depth of 200 µm in four consecutive steps of 50 µm each. Controls were treated similarly, but were not irradiated with UV-A. 20 eyes were examined in each experimental condition.
**Results:** The following depth-dependent differences were obtained: the first ablation from 0-50 µm microns showed no significant differences in ablation depth between cross-linked corneas and controls. For the three consecutive stromal ablations in deep stroma, we observed significantly less ablation in the cross-linked cornea when compared to non-cross-linked controls: 10.9 µm less for 50 - 99 µm (p=0.0001), 7.4 µm less for 100 - 149 µm (p=0.0003), and 7.2 µm less for 150 - 199 µm (p=0.003). Statistical analysis was performed using the Kruskal-Wallis test.
**Conclusions:** Following CXL, the excimer laser ablation rate in the cornea is significantly lower than in the untreated cornea and seems to be depth-dependent. Adaptation of the ablation rate and development of a nomogram for surface ablation in cross-linked ectatic corneas will be important to help improving best spectacle-corrected visual acuity.

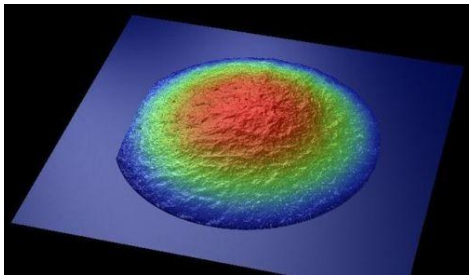



**Commercial Relationships: Olivier Richoz**, None; **Samuel Arba Mosquera**, SCHWIND eye-tech-solutions (E), SCHWIND eye-tech-solutions (P); **Thomas Magnago**, Schwind eye-tech-solutions (E); **Farhad Hafezi**, Schwind (F), Ziemer (F), PCT/CH 2012/000090 (P)

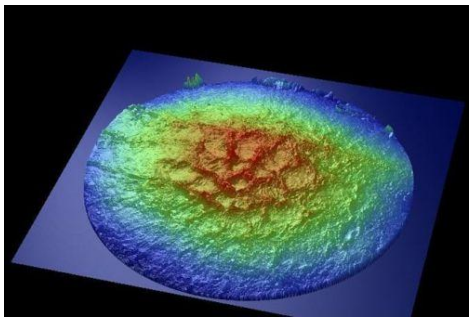
**Program Number:** 3715
**Presentation Time:** 3:45 PM - 4:00 PM
**Enhanced Screening for Ectasia Susceptibility among LASIK Candidates**
*Renato Ambrosio Jr[1, 2], Isaac C. Ramos[1], Ana Laura C. Canedo[1], Allan Luz[1, 2], Rosane Correa[1], Frederico P. Guerrra[1].* [1]Ophthalmology, Rio de Janeiro Cornel Tomography and Biomechanics Study Group, Rio de Janeiro, Brazil; [2]Ophthalmology, Federal University of Sao Paulo, Sao Paulo, Brazil.
**Purpose:** To develop objective methods to detect preoperative ectasia risk (susceptibility) among LASIK candidates considering clinical data, front surface curvature (topometric) data, and 3-D pachymetric and elevation (tomographic) data.
**Methods:** A retrospective nonrandomized study involved 23 eyes that developed ectasia after LASIK and 266 eyes with stable LASIK outcomes (minimal follow up of 12 months). Preoperative clinical data and Oculus Pentacam data were available for all cases. Classic ERSS (Ectasia Risk Score System) was calculated based on age, spherical equivalent, residual stromal bed, central thickness, and subjective classification of corneal topography (front surface axial curvature map). Front surface curvature (topometric) and tomographic (thickness profile and front/back elevation) indices were assessed. Non parametric Mann-Whitney's test was performed to assess differences between the groups. Different combinations that best distinguished ectasia and stable LASIK groups were created using Fisher's linear discriminant analysis (LDA) based on clinical parameters plus topometric data, and on clinical parameters plus tomographic data. The area under the ROC curve (AUC) were calculated for each LDA functions with pairwise comparisons.
**Results:** Statistically significant differences were found among the groups for all tested parameters (p<0.001), but preoperative spherical equivalent (SE). ERSS was equal or higher than 3 on 12 eyes from the ectasia group (sensitivity=52.17%) and on 48 eyes from the stable group (specificity=81.95%). The best LDA function including clinical parameters and topometric indices used IHD (index of height decentration), with AUC of 0.980 (sensitivity=100%; specificity=93.23%). The best LDA function combining clinical and tomographic parameters, included the Belin-Ambrósio Deviation (BAD-D), achieving 100% sensitivity and 97.4% specificity, with a statistically better AUC (0.994) than all individual parameters (p<0.001), and LDA functions.
**Conclusions:** Integrated analysis of clinical and objective topometric parameters were superior than the score that consider the classic subjective classification of topography. Tomographic data significantly enhanced the ability for screening ectasia risk among LASIK candidates. Similarly, clinical parameters significantly

improve the ability to detect ectasia susceptibility based on tomographic data. Further validation of the LDA functions are necessary.
**Commercial Relationships: Renato Ambrosio Jr**, Oculus (C), Alcon (C), AMO (C), Bausch & Lomb (C), Mediphacos (C), Pfizer (C); **Isaac C. Ramos**, None; **Ana Laura C. Canedo**, None; **Allan Luz**, None; **Rosane Correa**, None; **Frederico P. Guerrra**, None

**Program Number:** 3716
**Presentation Time:** 4:00 PM - 4:15 PM
**Laser thermal load induces characteristic changes in the corneal surface including asphericity**
*Sean J. McCafferty, Jim T. Schwiegerling*. Arizona Eye Consultants, Tucson, AZ.
**Purpose:** Examine excimer laser thermal load as the elusive etiology for corneal asphericity.
**Methods:** Cadaveric porcine eyes were pressurized and stabilized for processing and imaging. Both a scanning excimer laser and a CO2 laser were used to delivered a uniform disk of radiant energy to the exposed corneal stromal surface. Thermal load was determined by measuring corneal surface temperature during irradiation. Corneal profilometry was measured with broad-band optical interferometry before and after laser irradiation. Photomicrographs of the stromal surface were taken before and after irradiation and the images were superimposed to examine changes in positional marks examining mechanical alterations in the stromal surface.
**Results:** Uniform scanning excimer laser ablation to corneal stroma produces a significant central steepening and peripheral flattening in the central 3mm diameter. Q-values, measuring asphericity in the central 2mm of the cornea, were significantly lower pre-ablation than post ablation (-5.03+/-4.01vs.-52.4+/-18.7,respectively). Surface roughness increased significantly following ablation. The central 2mm of the stromal surface contracted by 2.21%+/-0.80% at a sustained temperature of 5C. Isolated thermal load from uniform CO2 laser irradiation without ablation also produces central corneal steepening and paracentral flattening in the central 3mm diameter. Q-values, measuring asphericity in the central 2mm of the cornea increased significantly and it was correlated with the temperature rise (R2=0.767). Surface roughness increased significantly and was also correlated with temperature rise (R2=0.851). The central stromal surface contracted and underwent characteristic morphologic changes with the applied thermal load which correlated well with the temperature rise (R2=0.818).
**Conclusions:** : The thermal load created by laser irradiation creates a characteristic spectrum of morphologic changes on the porcine corneal stromal surface which correlates to the temperature rise and is not seen inorganic, isotropic material. The highly similar surface changes seen with both lasers are likely indicative of temperature induced transverse collagen fibril contraction and stress re-distribution. Refractive procedures which produce significant thermal load should be cognizant of these morphological changes.
Corneal thermal response:



Before



After
**Commercial Relationships: Sean J. McCafferty**, None; **Jim T. Schwiegerling**, Alcon Laboratories (F), Wavetec (F), Visioneering (C)

**Program Number:** 3717
**Presentation Time:** 4:15 PM - 4:30 PM
**Effect of small aperture intra-corneal inlay on peripheral kinetic visual fields**
*Eric T. Brooker, Abhiram S. Vilupuru, George O. Waring*. AcuFocus, Irvine, CA.
**Purpose:** The KAMRA intra-corneal inlay (AcuFocus, Inc.) alleviates the symptoms of presbyopia by extending the depth of focus through small aperture optics. Following monocular implantation over a patient's coaxially sighted corneal reflex, the opaque inlay, which has an overall diameter of 3.8mm and a central aperture of 1.6mm, only allows central light rays to reach the retina, therefore increasing the eyes depth of focus. The main objective of this study was to evaluate visual acuity and the extent of the visual field following implantation of a small aperture corneal inlay.
**Methods:** Four subjects were implanted monocularly with the inlay in their non-dominant eye. Visual acuity and pupil size were recorded in conjunction with the visual field testing. Automated Goldmann kinetic perimetry was performed in both implanted and non-implanted eyes using the HAAG-STREIT Octopus 900. Goldmann size III4e targets moving at a speed of 5o/sec were presented along 16 isopters spanning the full extent of the visual field. Total area as well as extent of the field in superior, inferior, nasal and temporal directions was calculated. The data is presented as mean ± sd and statistical comparisons were performed using Student's t test.
**Results:** UCDVA at time of study was 0.035 ± 0.11 logMAR in the implant eye and -0.065 ± 0.07 logMAR in the non-implant eye. UCNVA was 0.01 ± 0.13 logMAR in the implant eye and 0.60 ± 0.05 logMAR in the non-implant eye. Mesopic pupil size for implant and non-implant eye was 5.5 ± 0.7 and 5.5 ± 1.1 mm respectively. Total area of the visual field in the implant eye was 12825 ± 2080 deg2 compared to 12321 ± 1383 deg2 in the non-implanted eye (p = 0.25). Extent of the visual field in the implant and non-implanted eyes was, superiorly (47.5 ± 12.5, 48 ± 11 deg), inferiorly (63.5 ± 1.3, 64.5 ± 0.6 deg), nasally (58.8 ± 7.4, 56.5 ± 3.3 deg) and temporally (83.3 ± 4, 83.5 ± 4 deg).
**Conclusions:** Implantation of a small aperture intra-corneal inlay improved UCNVA while maintaining UCDVA. The inlay did not decrease the extent of visual field as demonstrated by the lack of difference in total area and extent of kinetic visual field when comparing the implanted and non-implanted eyes.
**Commercial Relationships: Eric T. Brooker**, AcuFocus, Inc. (C); **Abhiram S. Vilupuru**, AcuFocus (E); **George O. Waring**, AcuFocus (C)