509 Corneal Refractive Surgery
Thursday, May 11, 2017 8:30 AM–10:15 AM
Exhibit/Poster Hall Poster Session
Program #/Board # Range: 5264–5297/B0217–B0250
Organizing Section: Cornea

Program Number: 5264 Poster Board Number: B0217
Presentation Time: 8:30 AM–10:15 AM
Quality of Vision After Femtosecond Laser or Mechanical Keratome for Laser In Situ Keratomileusis: A Prospective Randomized Contralateral Eye Study
Irma Muminovic, Edward E. Manche. Ophthalmology, Stanford University, Palo Alto, CA.

Purpose: To compare the effect of femtosecond laser or mechanical keratome for LASIK on subjective quality of vision.

Methods: Fifty-one patients were randomized to receive femtosecond laser for LASIK for one eye and mechanical keratome for LASIK for the fellow eye. Study participants completed a questionnaire assessing quality of vision and visual symptoms (daytime and nighttime glare, nighttime and daytime clarity, halos, haze, dry eye, severe dry eye, grittiness, fluctuating vision, and double vision) at postoperative months 1, 3, 6, and 12.

Results: At 1, 3, 6, and 12 months postoperatively, there was no significant difference in any individual symptoms between the femtosecond laser and mechanical keratome group. When comparing their vision before and after LASIK at postoperative month 12, 84.4% patients reported better vision after LASIK in the eye treated with mechanical keratome, whereas 80% patients reported better vision after LASIK in the eye treated with femtosecond laser (P=0.3901). Seven percent of patients reported worse dry eye symptoms in the eye treated with mechanical keratome compared to before LASIK while 9% of patient reported worse dry eye symptoms in the eye treated with femtosecond laser compared to before LASIK (P=0.3489). When comparing fluctuation in vision, 9% of patient reported more fluctuation of vision in the eye treated with mechanical keratome while 13% of patients reported more fluctuation of vision in the eye treated with femtosecond laser (P=0.2540).

Conclusions: At 12 months after surgery, there were no significant differences between reported quality of vision between femtosecond laser and mechanical keratome for LASIK.

Commercial Relationships: Irma Muminovic, None; Edward E. Manche, Calhoun Vision, Inc. (I), Allergan, Inc. (C), Veralas, Inc. (I), Seros Medical, LLC. (P), Carl Zeiss Meditec, Inc. (C), AbbVie Medical Optics, Inc. (C), Avellino Laboratoires, Inc. (C), Seros Medical LLC, (I), Guidepoint Global (C)

Program Number: 5265 Poster Board Number: B0218
Presentation Time: 8:30 AM–10:15 AM
Tear film proteomics after LASIK surgery
Janika Näätinnen1, Antti Jylhä2, Petri Mäkinen1,2, Juhani Pietilä1,2, Anne Huhtala1, Teppo Rajala1, Vesa Ahlo3, Ulla Aapola1, Roger W. Beueraman1,4, Hannu M. Uusitalo5,6,7. 1SILK, Department of Ophthalmology, University of Tampere, School of Medicine, Tampere, Finland; 2Silmäasema Eye Hospital, Tampere, Finland; 3TAUH Eye Center, Tampere University Hospital, Tampere, Finland; 4Singapore Eye Research Institute, Singapore, Singapore.

Purpose: To determine the efficacy of interface bonding with corneal crosslinking after laser in situ keratomileusis (LASIK) ex vivo using rose bengal/green light and riboflavin/UV light.

Methods: A LASIK-flap (90 µm) was created in ex vivo rabbit eyes using a femtosecond laser. After the dissection, CXL was performed to seal the interface. In one group, interface CXL was performed using rose bengal and green-light whereas in another group CXL was performed using riboflavin and UV light. In both groups the irradience, radiant exposure, dye concentration and imbibition time were varied to identify parameters producing strongest adhesion. In a control group only LASIK was performed. After the bonding and in the control corneas, the maximal shear force required to separate the flap from the stroma was measured.

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Biomechanical changes associated with LASIK flap creation and rapid cross-linking measured with Brillouin microscopy

James B. Randleman, Giuliano Scarcelli. Ophthalmology, USC Roski Eye Institute, Atlanta, GA; 2School of Engineering, University of Maryland, College Park, MD.

Purpose: To evaluate the biomechanical changes occurring after LASIK flap creation and rapid corneal cross-linking (CXL) measured with Brillouin light microscopy.

Methods: Eleven porcine eyes were evaluated. Each eye was measured by Brillouin light microscopy sequentially in the following order: virgin state, after LASIK flap creation, and after rapid CXL. Each eye served as its own control. Depth profile of the Brillouin frequency shift was computed to reveal the depth-dependent changes in corneal stiffness.

Results: There was a statistically significant reduction of Brillouin shift (reduced corneal stiffness) after LASIK flap creation compared to virgin corneas across total corneal thickness, as well as within the anterior and central, but not posterior, stromal regions. There was a small increase in Brillouin shift after rapid cross-linking that was not statistically or clinically significant across total corneal thickness or for any specific stromal region.

Conclusions: LASIK flap creation significantly weakened the anterior and central cornea as expected. Rapid corneal cross-linking had no significant effect on Brillouin shift in porcine eyes. Brillouin microscopy could become a useful monitoring tool to evaluate the biomechanical impact of corneal refractive procedures and corneal cross-linking protocols.

Commercial Relationships: James B. Randleman, None; Giuliano Scarcelli, None

Support: Research to Prevent Blindness USC Roski Eye Institute

Program Number: 5267 Poster Board Number: B0220
Presentation Time: 8:30 AM–10:15 AM

Corneal collagen crosslinking in post- LASIK ectasia

Michele A. Pacheco1, Arturo J. Ramirez-Miranda1, Juan Carlos Serna-Ojeda1, Alejandro Navas1, Aida Jimenez-Corona1, Omar Santana-Cruz2, Enrique O. Graue-Hernandez2, 1Córmica and Refractive Surgery, Instituto de Oftalmología Conde de Valenciana, Ciudad de México, Mexico; 2Instituto de Oftalmología Conde de Valenciana, Ciudad de México, Mexico; 3Epidemiología Ocular y Salud Visual, Instituto de Oftalmología Fundación Conde de Valenciana, Ciudad de México, Mexico.

Purpose: To report visual, refractive and topographic outcomes in post-LASIK ectasia subjects that underwent corneal collagen crosslinking (CXL).

Methods: Methods: Single center consecutive case series. Patients older than 18 years old with post-LASIK ectasia diagnosis and progression evidence (increase Kmax >1D), who underwent CXL were included. Avedro protocol was used as epithelium on modality the variation of the loss of shape discrimination caused by transient glare.

Results: 46 myopia patients and 10 normal people were recruited in this study, only the right eyes needed to be measured. Follow-up time included preoperation, 1 week, 1 month postoperatively. The subject should finish the measurement 3 times both with glare and without glare. The shape discrimination threshold with/without glare was defined as R(on)/ R(off). The difference between R(on) and R(off) was equal to R(glare), which represented the loss of shape discrimination caused by transient glare.

Conclusions: After LASIK, the shape discrimination threshold without glare kept stable; the shape discrimination threshold with glare decreased which indicated more subtle shape discrimination; the postoperative influence caused by disability glare on shape discrimination seemed slighter, and tended to be steady after 1 month.

The shapes used in this study

Commercial Relationships: LIN MENG, None; Bin B. Su, None; Zhen Y. Wu, None; Liang Hu, None

Program Number: 5269 Poster Board Number: B0222
Presentation Time: 8:30 AM–10:15 AM

The effect of transient glare on shape discrimination threshold after laser in situ keratomileusis

LIN MENG1, Bin B. Su1, Zhen Y. Wu1, Liang Hu1. 1The Eye Hospital of Wenzhou Medical University, Wenzhou, China; 2School of Ophthalmology and Optometry, Wenzhou Medical University, Wenzhou, China.

Purpose: To evaluate the shape discrimination threshold in dark, with glare and without glare, before and after LASIK. And to determine
in pachymetry >370um - <400um, and epithelium off in pachymetry >400um. Pre and postoperative uncorrected (UCVA) and best corrected visual acuity (BCVA), Kmin, Kmax, spherical equivalent and pachymetry were measured. Paired T – test using Stata 13.1 was used for the analysis.

**Results:** Results: Twenty eyes of 12 patients were enrolled, mean age was 37 years old (range 22 to 58 years) with a mean follow-up of 6 months (range 4 to 14 months). Increase in spherical equivalent was found, however there was no statistically significant difference between preoperative (-3.46D ±5.41) and postoperative (-3.53D±5.05) value (p=0.93). Also non-significant change was noted in UCVA, an improvement from 0.93 logMar (20/167 Snellen) preoperative to 0.827 logMar (20/134 Snellen) postoperative (P=0.39), and in BCVA 0.319 logMar (20/41 Snellen) preoperative to 0.264 logMar (20/36 Snellen) postoperative (P=0.32). An increase of 0.58D (± 1.78SD, P=0.16) in Kmin value, 0.79D (± 1.16SD, P=0.0065) in Kmax value, and a decrease in 22.6um (± 56.43SD, P=0.08) in pachymetry values were found. Eight patients (40%) presented progression during the follow-up.

**Conclusions:** Conclusion. An increase in postoperative keratometric values at 6 months was found, however no statistically significant, and expecting a posterior decrease in longer follow-up. There was an improvement in UCVA and BCVA, probably due to stabilization in corneal biomechanical properties posterior to CXL, and a reduction in pachymetry values is possibly secondary to stromal compaction posterior to CXL. With a high rate of progression after treatment, post-LASIK ectasia remains a challenging disease.

**Commercial Relationships:** Michele A. Pacheco, None; Arturo J. Ramirez-Miranda, Thea Laboratories (C), Carl Zeiss Meditec (C); Juan Carlos Serna-Ojeda; Alejandro Navas, Alcon Laboratories (C); Aida Jimenez-Corona, None; Omar Santana-Cruz, None; Enrique O. Graue-Hernandez, None.

**Program Number:** 5270 **Poster Board Number:** B0223

**Presentation Time:** 8:30 AM–10:15 AM

**Algorithms for Reducing Post-Operative Induction of Spherical Aberration for LASIK Surgeries**

Guang-ming G. Dai, Dimitri Chernyak. R & D, Abbott Medical Optics, Milpitas, CA.

**Purpose:** To investigate treatment algorithms for reducing post-operative induction of spherical aberration for LASIK surgeries.

**Methods:** Following a previous approach [A. Fabricant, G.-m. Dai, and D. Chernyak, “Optimization of linear filtering model to predict post-LASIK corneal smoothing based on training data sets,” Applied Mathematics 4, 1694-1701 (2013).] for using an optimized linear filter (OLF) model to reduce post-operative induction of spherical aberration for myopic LASIK surgeries, we proposed an improved approach that imposes a criterion such that the kernel does not have a wing that would cause instability during optimization. The optimization also includes both myopic and hyperopic data to increase the predictability of intended versus achieved refractions. In addition, various weighting factors are introduced during the optimization to fine-tune the optimized outcomes. A new technique is devised to find the best SNR (signal to noise ratio) value in the deconvolution. Finally, the power spectrums for the OLF as well as the inverse kernel are plotted against those of the previous kernels to make sure their similarity in the spatial frequency domain.

**Results:** Analysis of the clinical study outcome [G. Dai, D. Chernyak, S. Kashtyrrangan, and J. Tarrant, “Outcomes for clinical studies to reduce post-operative induction of spherical aberration for myopic LASIK surgeries,” ARVO abstract, 2016.] using the previous kernel indicated that it is too weak, resulting in sub-optimal reduction of spherical aberration in the clinical study. It was found that unbound kernels (kernels with wings) have the following problems: (1) no biological support; (2) unstable optimization; (3) no natural limit on the kernel size; (4) with fluctuating power spectrum. Hence, the bound kernels are introduced. Analytical solutions are obtained for the cutoff of bound kernels at zero first-derivative for 2-, 3-, and 4-parameter kernels. A multi-level optimization approach has been developed to enable the realization of attaining the optimized kernel both in speed and precision. The proposed new kernel results in similar ablation depth to CustomVue for myopia and about 25% deeper for hyperopia.

**Conclusions:** It is possible to further improve the predicted clinical outcome with a new optimized linear filter for reducing the induction of spherical aberration for LASIK surgeries.

**Commercial Relationships:** Guang-ming G. Dai, Abbott Medical Optics (E); Dimitri Chernyak, Abbott Medical Optics (E).

**Program Number:** 5271 **Poster Board Number:** B0224

**Presentation Time:** 8:30 AM–10:15 AM

**Tears mirror the stromal response to surgery- Novel insights into molecular changes in SMILE and LASIK**

Natasha Pahuja, Krishnatej Nishtala, Rohit Shetty, Abhijit Sinha Roy, Arkasubhra Ghosh. ‘Cornea & Refractive, Narayana Nethralaya, Pimple Saudagar, Pune, India; ‘GROW laboratories, Narayana Nethralaya foundation, Bangalore, India.

**Purpose:** Corneal wound healing response to vision correction surgeries depends on injury imposed on the cornea. Using quantitative proteomics we studied corneal response to LASIK and SMILE surgeries at the stroma and in patient tears longitudinally collected up to 3 months post surgery.

**Methods:** Paired cadaver eyes (n=3) not suitable for transplantation were randomly selected to perform LASIK and SMILE surgeries. The cornes were treated for 6 diopter with maximum ablation of 74-75µ and 85µ for LASIK and SMILE respectively. Tears were collected on Schirmer’s strip in patients (n=3) who underwent LASIK and SMILE surgeries on contralateral eyes at pre-op, 1 and 3 month post-surgery. Independent ITRAQ quantitative proteomics analyses were performed on the stromal tissue and in patient tears.

**Results:** Increased levels of cytokeratins and cell cycle proteins were observed in stroma and in tears of SMILE patients at 3 months indicating faster wound healing in SMILE. Reduced levels of ECM proteins such as COL6A1, A2 observed in SMILE indicate a stable ECM. Lys C, an inflammatory protein was observed at lower levels in SMILE indicating a modulated inflammatory response in SMILE stroma and in tears 3 month post surgery whereas LASIK is associated with extensive ECM remodeling and more inflammation.

**Conclusions:** Quantitative proteomics analysis reveals novel molecular insights into wound healing mechanism in stroma and patient tears. Our results indicate faster corneal wound healing and stable ECM in response to SMILE whereas these processes appear to be more dynamic in LASIK besides strong inflammatory response.

**Commercial Relationships:** Natasha Pahuja, None; Krishnatej Nishtala, None; Rohit Shetty, Carl Zeiss (F); Abhijit Sinha Roy, Carl Zeiss (F); Arkasubhra Ghosh, Carl Zeiss (F).
**Program Number:** 5272 **Poster Board Number:** B0225

**Presentation Time:** 8:30 AM – 10:15 AM

**Topography-guided (TG) LASIK vs Small Incision Lenticule Extraction (SMILE) : Posterior and Anterior Corneal Power Outcomes**  
Sacharita Boddu	extsuperscript{1}, Laurence T. Sperber	extsuperscript{1}, A. J. Kanellopoulos	extsuperscript{1,2}  
	extsuperscript{1}Ophthalmology, NYU School of Medicine, New York, NY;  
	extsuperscript{2}Lasersvision.gr Clinical and Research Eye Institute, Athens, Greece.

**Purpose:** Evaluate safety, efficacy and changes of anterior and posterior corneal power of topo-guided LASIK vs. SMILE in contralateral eyes, in myopic laser refractive surgery.

**Methods:** In 22 myopic patients: 22 eyes had TG LASIK, and the contralateral eye had SMILE. Preoperative and postoperative evaluation of: spherical equivalent (SE) (SE). The eyes were divided in two groups of spherical equivalent (SE). The first group contains eyes with SE between -10 and -5.01 (High Zone) while the second group contains eyes with SE from -5 to 0. All data for corneal power were extracted from Optovue OCT device.

**Results:** In the case of high zone, the anterior corneal power for SMILE technique was preoperatively 49.96±167 D and 43.2±1.99 D postoperatively. On the other hand, when EX500 method was used, preoperatively the corneal power was 50.2±1.58 D and 42.57±1.84 D postoperatively. The corresponding results for mild SE zone in the case of SMILE technique were: 50.47±1.77 D preoperatively and 46.54±1.71 D. For the EX500 technique the corneal power pre-op and post-op was 49.35±2.43 D and 46.50±2.68 D respectively. Concerning posterior corneal power when SMILE method was used, in case of high SE zone the posterior corneal power changed from -6.16±0.23 D pre-op to 6.18±0.28 D post-op. When EX500 method was used the corresponding results were 6.21±0.22 D and -6.24±0.22 D. Finally in the case of mild SE zone the posterior corneal power increased from -6.23±1.67 to -6.26±0.26 D when SMILE method was applied, while for the eyes that surged with EX500 technique the posterior corneal power was -6.15±0.37 D pre-op and -6.16±0.38 D post-op.

**Conclusions:** Anterior and posterior corneal power was calculated after SMILE and EX500 refractive operations. The results presented, clearly showed that after EX500 operation, anterior corneal power is lower in comparison to SMILE operation in high SE zone. In mild SE zone the anterior corneal power is almost the same for the both methods. On the other hand the posterior corneal power remains unchanged, regardless the SE zone and the operation method.

**Commercial Relationships:** Sacharita Boddu, None; Laurence T. Sperber; A. J. Kanellopoulos, Alcon/WaveLight (C), i-Optics (C), Zeiss (C), ISP Surgical (C), Keramed (C), Avedro (C), Allergan (C)

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**Program Number:** 5273 **Poster Board Number:** B0226

**Presentation Time:** 8:30 AM – 10:15 AM

**Femtosecond Laser in situ keratomileusis versus Epi-LASIK: Visual outcomes and complications**  
Samar A. Al-Swailem, Mohammed Al-Amro. Anterior Segment, King Khaled Eye Specialist Hosp, Riyadh, Saudi Arabia.

**Purpose:** To compare the visual outcomes and complications of femtosecond laser in situ keratomileusis (FS-LASIK) and femtosecond laser sub-Bowman keratomileusis (FSBK) with those of surface treatment by epithelial laser in situ keratomileusis (Epi-LASIK) for the correction of low-to-moderate myopia.

**Methods:** This retrospective review comprised all eyes of FS-LASIK (n= 242), FSBK (n= 62) and Epi-LASIK (n=183) performed between Jan 2008 and Dec 2013. Preoperative and postoperative assessment included Snellen uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), refraction, and complications. Patients were followed for at least 3 months.

**Results:** The median age at surgery was 29.4 years (FS-LASIK), 28 years (FSBK) and 31.6 years (Epi-LASIK) (P < 0.01). The median preoperative values were: central corneal thickness, 577±36 um (FSBK), 566±35 (FSBK) and 550±35 (Epi-LASIK) (P < 0.001); spherical equivalent, -3.75D (FS-LASIK), -4.0D (FSBK) and -3.75D (Epi-LASIK) (P < 0.01); mean keratometry, 43.2D (FS-LASIK), 42.7D (FSBK) and 42.8D (Epi-LASIK); and BCVA of 20/20, 91.7% (FS-LASIK), 87.3% (FSBK) and 84.4% (Epi-LASIK) (P = 0.06). Flap thickness was: 120.2±4.6 (FS-LASIK), 101±3.2 (FSBK) and 50.8±6.2 (Epi-LASIK) (P < 0.001). Visual recovery was slower after Epi-LASIK. A successful refractive surgery (most recent postoperative UCVA of 20/40 or better) was acquired in 95% (FS-LASIK), 96.8% (FSBK) and 92.3% (Epi-LASIK) of eyes. Moderate myopia (-2.5D to -6D) (P = 0.003) and the use of mitomycin C (P = 0.0003) were factors associated with success. Gaining of 1 line or more was attained in 95.0% (FS-LASIK), 98.3% (FSBK) and 93.9% (Epi-LASIK) of eyes (P = 0.11). Loss of 1 line occurred in one eye after Epi-LASIK.

**Conclusions:** Both thin-flap LASIK (FSBK) and conventional thick-flap LASIK (FS-LASIK) are safe and effective procedures to correct low-to-moderate myopia. Both femtosecond flap procedures provided better outcomes than surface ablation (Epi-LASIK) procedure. In eyes requiring deeper ablation, FSBK surgery provided slightly higher success rate.

**Commercial Relationships:** Samar A. Al-Swailem, None; Mohammed Al-Amro, None
Refractive outcomes of moderate astigmatism correction using wavefront-guided and wavefront-optimized PRK and LASIK

Kose K. Sia1, Denise S. Ryan1, Bruce Rivers1, Joseph F. Pasternak2, Richard D. Stutzman3, Lamarr Peppers4, Jennifer B. Eaddy1, Lorie Logan1, Kraig S. Bower1. 1Warfighter Refractive Eye Surgery Program, Fort Belvoir Community Hospital, Fort Belvoir, VA; 2Ophthalmology, Walter Reed National Military Medical Center, Bethesda, MD; 3Ophthalmology, George Washington University, Washington, DC; 4Ophthalmology, Johns Hopkins University, Baltimore, MD.

Purpose: To evaluate the refractive outcomes of wavefront-guided (WFG) and wavefront-optimized (WFO) photorefractive keratectomy (PRK) and laser-assisted in-situ keratomileusis (LASIK) in myopic eyes with moderate refractive cylinder.

Methods: Subjects undergoing either PRK or LASIK for myopic astigmatism were randomized to either WFG or WFO treatment.

WFG treatment surgeries were performed using the VISX CustomVue STAR S4 IR (Abbott Medical Optics) and WFO surgeries were done using WaveLight Allegretto Wave EyeQ (Alcon Surgical). The target refraction was emmetropia in all eyes. Eyes with preoperative refractive cylinder ranging from 1.00 to 2.75 diopters (D) were included in the data analysis. Refractive outcomes including astigmatic changes were assessed and compared among four treatment groups: WFG PRK, WFG LASIK, WFO PRK, and WFO LASIK groups. Vector analysis for refractive astigmatism was performed using Alpins method.

Results: Data analysis included 117 eyes (40 WFG PRK, 25 WFG LASIK, 25 WFO PRK and 27 WFO LASIK) of 76 subjects (mean age 31.5 years ±7.3). Preoperatively, there were no significant differences among treatment groups in either refractive sphere (p=0.45), cylinder (p=0.69) or sphercial equivalent (p=0.48). At 6 months postoperatively, there were no significant differences among groups in terms of eyes achieving uncorrected distance visual acuity of 20/20 or better (100% WFG PRK, 100% WFG LASIK, 96.0% WFO PRK, and 95.7% WFO LASIK, p=0.48); spherical equivalent within ±0.50 D of emmetropia (91.2% WFG PRK, 83.3% WFG LASIK, 88.0% WFO PRK, and 100% WFO LASIK, p=0.25); refractive astigmatism (non-vector) ≤0.50 D (94.1% WFG PRK, 87.5% WFG LASIK, 84.0% WFO PRK, and 100% WFO LASIK, p=0.19). Refractive astigmatism corrections were also comparable among treatment groups in terms of magnitude of error (-0.07 D WFG PRK, 0.00 D WFG LASIK, -0.02 D WFO PRK, and 0.04 D WFO LASIK, p=0.53); angle of error within ±15 degrees (100% WFG PRK, 95.8% WFG LASIK, 88.0% WFO PRK, and 100% WFO LASIK, p=0.08) and correction index (0.94 WFG PRK, 1.01 WFG LASIK, 1.02 WFO PRK, and 1.03 WFO LASIK, p=0.39).

Conclusions: Wavefront-guided and wavefront-optimized PRK and LASIK were effective in treating myopic eyes with moderate refractive cylinder. Astigmatic changes induced by refractive surgery using either laser platforms were comparable.

Commercial Relationships: Rose K. Sia, None; Denise S. Ryan, None; Bruce Rivers, None; Joseph F. Paster, None; Richard D. Stutzman, None; Lamarr Peppers, None; Jennifer B. Eaddy, None; Lorie Logan, None; Kraig S. Bower, None.

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Clinical Trial: NCT01097525
Conventional corneal cross-linking is an intervention that has been demonstrated to be effective in halting disease progression in ectatic pathologies as keratoconus. This procedure utilizes riboflavin and ultraviolet-A. However, it has some drawbacks is a long procedure time, and limitation to only treating corneas greater than 400 µm thick. For these reasons, another techniques are being developed such as collagen cross-linking that uses green light to activate rose bengal (RB). Our aim was to evaluate corneal wound healing after treatment with this new collagen cross-linking protocol using rose bengal dye and green light.

**Methods:** One cornea of 20 New Zealand rabbits was de-epithelialized (DE) in an 8 mm-diameter circle and, in another group (n=25), the de-epithelialized corneas were then stained with 0.1% rose bengal for 2 minutes and exposed to green light (532 nm) for 7 minutes (RGX). The contralateral eyes of all rabbits received no treatment and served as controls. The animals were followed by clinical observations including fluorescein staining, slit lamp exam and pachymetry. After euthanasia at 2, 30 and 60 days, the healing events were analyzed. Analyses of cell death (by TUNEL), cell proliferation (by BrdU) and cell differentiation to myofibroblast (by αSMA) were carried out. In this prospective study. Three measurements of each eye of TCT, steep(K1), flat keratometry(K2) and Km were obtained. Haze was measured using densitometry software on PentacamHR. Effect of post ACXL haze on the measurement of thinnest corneal thickness(TCT) and mean keratometry(Km).

**Results:** Multiple models were composed to assess the necessity of preoperative IF-pIOL simulation, because mean preoperative ACD (2.33±0.36mm), sCD (2.40±0.33mm) and sPD (1.90±0.29mm) were highly correlated (p<0.001). All models used preoperative ECD, time, covariate (ie, ACD, sCD or sPD), and interaction between time and covariate to predict ECD. Only interactions between time and ACD (p=0.002) or sCD (p=0.005) were significant predictors. Using the mean preoperative ECD of 2725.4 cells/mm² and the mean ACD or sCD, both models reached a critical ECD of 1500 cells/mm² after 21 years (range 15 to 32 years when using the mean ±1SD ACD or sCD), with a predicted total 5-year EC-loss of -12% (range -15 to -9% when using the mean±1SD ACD or sCD).

**Conclusions:** The results of both models emphasize smaller anterior chamber dimensions as risk factors and predictors of higher EC-loss, and suggest IF-pIOL simulation does not add a significant benefit in predicting EC-loss in IF-pIOL implanted myopic eyes.

**Commercial Relationships:** Ashima Bajaj, None; Rohit Shetty, None; Rashmi Deshmukh, None; Tushar Grover, None; Natasha Pahuja, None

**Program Number:** 5279 Poster Board Number: B0232
**Presentation Time:** 8:30 AM–10:15 AM

Influence of post crosslinking haze on the repeatability of topography machines

**Purpose:** To assess the repeatability of corneal measurements using various topographers post accelerated collagen cross-linking (ACXL) and to study effect of post ACXL haze on the measurement of thinnest corneal thickness(TCT) and mean keratometry(Km).

**Methods:** Sixty eyes of 60 patients who had undergone ACXL a year before underwent imaging with scanning slit (OrbscanII) and three Scheimpflug imaging devices (PentacamHR, Sirius and Galilei) in this prospective study. Three measurements of each eye of TCT, steep(K1), flat keratometry(K2) and Km were obtained. Haze was measured using densitometry software on PentacamHR. Effect of haze on repeatability of TCT and Km was evaluated using regression models. Coefficient of repeatability (CRw) and coefficient of variation (CVw) were used to test repeatability.

**Results:** The mean parameter measurements with different instruments were compared by repeated measures ANOVA. Twenty-seven female and 33 male patients with a mean age of 23 ± 5.32 years(range15-36) were analyzed. CRw for TCT in Orbscan was significantly worse than those of the Scheimpflug devices (p<0.05) whereas K1, K2 did not show statistically significant difference. CVw for TCT, K1 and K2 for Orbscan was significantly higher than those of Scheimpflug devices (p<0.05). Haze was maximum in anterior and central 0-2mm zone of cornea. Haze affected TCT measurement of Orbscan (p=0.05) in all zones while its repeatability was affected with PentacamHR and Sirius (p=0.05). Km was affected by haze on PentacamHR (p=0.05) while other topographers showed good measurements. Km repeatability was unaffected for all devices.

**Conclusions:** Scheimpflug devices are less variable while measuring corneal parameters in post ACXL eyes than slit scanning device. Galilei parameters were the least affected by haze. Hence topography measurements in the presence of haze should be interpreted with caution.

**Commercial Relationships:** Carmen Martinez-Garcia, Irene Kochevar, Patricia Gallego-Muñoz, Lucia Ibares-Frias, Elvira Lorenzo, Susana Marcos, Cell Biology, University of Valladolid, Valladolid, Spain; Wellman Center for Photomedicine, Harvard Medical School, Boston, MA; CSIC, Instituto de Optica, Madrid, Spain; Gde Técnicas Ópticas para el Diagnóstico, Madrid, Spain.

**Purpose:** Conventional corneal cross-linking is an intervention that has been demonstrated to be effective in halting disease progression in ectatic pathologies as keratoconus. This procedure utilizes riboflavin and ultraviolet-A. However, it has some drawbacks is a long procedure time, and limitation to only treating corneas greater than 400 µm thick. For these reasons, another techniques are being developed such as collagen cross-linking that uses green light to activate rose bengal (RB). Our aim was to evaluate corneal wound healing after treatment with this new collagen cross-linking protocol using rose bengal dye and green light.

**Methods:** One cornea of 20 New Zealand rabbits was de-epithelialized (DE) in an 8 mm-diameter circle and, in another group (n=25), the de-epithelialized corneas were then stained with 0.1% rose bengal for 2 minutes and exposed to green light (532 nm) for 7 minutes (RGX). The contralateral eyes of all rabbits received no treatment and served as controls. The animals were followed by clinical observations including fluorescein staining, slit lamp exam and pachymetry. After euthanasia at 2, 30 and 60 days, the healing events were analyzed. Analyses of cell death (by TUNEL), cell proliferation (by BrdU) and cell differentiation to myofibroblast (by αSMA) were carried out. In addition, the loss of keratocytes and the repopulation of the corneal stroma were quantified in hematoxylin-eosin stained sections.

**Results:** Wound closure was slower after RGX (4.4 days) than after DE (3.3 days). Edema was greater in DE than RGX eyes, maximal at 2 days and decreased at day 4 in both treated groups. Cell death was restricted to the anterior central cornea stroma, where the cellular decrease in RGX corneas was not significantly different from DE eyes. Cell proliferation in the epithelium and stroma was visible at 2 days. In both DE and RGX corneas recovery of the epithelium was complete at day 30, but cell repopulation of the stroma was not complete at 60 days.

**Conclusions:** The healing response in corneas after photo-crosslinking with RGX is very similar to that observed after de-epithelialization alone suggesting that, along with its short treatment time and limited effect on keratocytes, RGX has high potential for clinical cornea stiffening.

**Commercial Relationships:** Carmen Martinez-Garcia, Irene Kochevar, Patricia Gallego-Muñoz, Lucia Ibares-Frias, Elvira Lorenzo, Susana Marcos, None

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**Program Number:** 5281
**Poster Board Number:** B0234
**Presentation Time:** 8:30 AM–10:15 AM

**Comparison of Iris Registration using Scotopic and Photopic Eye Images**

**Purpose:** Current iris registration (IR) uses a scotopic eye image from the diagnostic device as a reference to register the photopic eye image from the laser device. However, iris distortions caused by pupil dilation and constriction may cause IR failure due to lack of matching iris features identified from the two images. This paper investigates IR using scotopic eye images and photopic eye images from the diagnostic device.

**Methods:** This study included 60 eyes that underwent LASIK refractive surgery. Of the 60 eyes, there were 32 paired scotopic and photopic eye images simultaneously captured by iDesign Advanced WaveScan Studio system (AMO Development, LLC), and 60 eye images captured by STAR S4 IR® system (AMO Development, LLC). All images were analyzed to extract pupil and iris data with the image processing algorithms implemented on iDesign® system and STAR S4 IR® system. An IR test program, with the IR algorithms implemented on STAR S4 IR® system, was used to verify the IR functionality using scotopic or photopic eye image as reference to register the laser eye image. McNemar’s test was used to assess the significance of the difference in successful capture rates between the scotopic eyes and photopic eyes. A p-value less than 0.05 was used to demonstrate statistically significant difference between the results.

**Results:** Compared to the scotopic eye image, the pupil size and the iris features in the photopic eye image are more similar to that in the eye image under STAR S4 IR® system illumination. IR capture rate with photopic eye images increases 5.92%, and this IR improvement on IR capture rate is statistical significant (p-value=0.0002). IR passes with photopic eye images are mostly based on circular fittings which provides more precise cyclotorsion angle (CT) compared to elliptical fittings. CT angles of laser eye images calculated from the IR using scotopic eye images is equivalent to that calculated from the IR using with photopic eye image with the compensation of the CT angle changes between the scotopic images and photopic images.

**Conclusions:** IR with photopic eye images is more efficiency than that with scotopic eye images. Using both scotopic and photopic eye images as reference to register laser eye images can improve the IR capture rate with equivalent IR functionality.

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**Commercial Relationships:** Li Chen

**Clinical Trial:** NCT01220466

**Program Number:** 5282
**Poster Board Number:** B0235
**Presentation Time:** 8:30 AM–10:15 AM

**Hydrogel Sealant in Prevention of Epithelial Ingrowth**

**Purpose:** Epithelial ingrowth has been reported in up to 32% of post-LASIK enhancement cases, and clinically significant epithelial ingrowth has been reported in 1.7% of post-LASIK enhancement cases. Poor flap adhesion is thought to allow for epithelial invasion. We hypothesize that use of a hydrogel sealant (ReSure) will help promote flap adhesion and prevent clinically significant epithelial ingrowth in post-LASIK enhancement cases.

**Methods:** This prospective study, a single surgeon performed LASIK enhancement on 26 eyes over the course of 2016. The surgeon lifted the existing flap and treated the residual refractive error with an excimer laser before sealing the flap with hydrogel (Group A).

In addition, a retrospective review of 104 eyes that underwent LASIK enhancements from 2013–2014, with the same surgeon and the same technique, but that did not receive hydrogel, were reviewed (Group B).

All enhancements were done using the EyeQ or Visx Star S4 lasers, and patients were examined for epithelial ingrowth at subsequent visits. The risk factors for epithelial ingrowth were identified and compared between groups.

**Results:** In Group A, 85% of patients were 20/20–25 at one month. There was a 12% incidence of epithelial ingrowth and a 0% incidence of clinically significant epithelial ingrowth at a follow-up interval of up to 10 months post enhancement. In Group B, there was a 24% incidence of epithelial ingrowth and a 6.7% incidence of clinically significant epithelial ingrowth without using hydrogel at a follow-up interval of up to two years post enhancement. There were no vision-threatening complications in the hydrogel group. The risk factors for epithelial ingrowth after LASIK enhancement include microkeratome flap creation, LASIK enhancement more than 10 years after initial LASIK, Anterior Basement Membrane Dystrophy, initial LASIK for myopia, enhancement for myopia, age greater than 40, and superior hinge location.

**Conclusions:** Hydrogel sealant effectively reduced clinically significant epithelial ingrowth to 0% post-LASIK enhancement at up to 10 months post-op. In addition, hydrogel reduced mild epithelial ingrowth from 25% to 12%. Therefore, the use of a hydrogel sealant is a safe and effective option to prevent epithelial ingrowth.

**Commercial Relationships:** andrew R. davis, None; Mario J. Rojas, None; Peyton Neatrour, None

**Program Number:** 5283
**Poster Board Number:** B0236
**Presentation Time:** 8:30 AM–10:15 AM

**Three-Month Outcomes from a Prospective, Randomized, Contralateral, Eye-to-Eye Comparison of Wavefront-Guided and Wavefront-Optimized PRK in Myopes**

**Purpose:** To compare wavefront WF-optimized and WF-guided PRK in myopic patients.

**Methods:** Forty eyes from 20 participants were prospectively randomized to receive either WF-optimized or WF-guided PRK with the WaveLight Allegretto Eye-Q 400-Hz excimer laser (Alcon, Inc., Hünberg, Switzerland). One eye was randomized to receive WF-guided PRK and the fellow eye was randomized to receive WF-optimized PRK. Eyes were randomized according to ocular dominance. Main outcome measures included uncorrected distance visual acuity (UDVA), corrected distance visual acuity (CDVA), <5% and <5% contrast sensitivity, and WF aberrometry data. Postoperative measurements were analyzed at three months.

**Results:** The frequency with which the WF-optimized and WF-guided group attained a refractive error within ±0.25 diopters of emmetropia was not significantly different between groups (p >0.05). Furthermore, the frequency with which the WF-guided and WF-optimized groups achieved postoperative UDVA of ≥20/16 or ≥20/20 and the frequency with which the groups lost 1 or 2 or more lines or maintained their preoperative CDVA were not statistically different from each other (all P >0.05). There were no statistically significant differences in UDVA, CDVA, contrast sensitivity,
Mitomycin-C Aqueous Humor Concentration in Rabbit after PRK or TPRK for -3D, -6D or -9D Treatment

Ye Yuan1,2, Davis K. Lui1, Shu Liu2, Y.Y. Xiao3, K.O. Chu4, Y Wang4, Chi Pui Pang5, Dennis S. Lam1,2. 1Sun Yat-sen University, Guangzhou, China; 2C-MER (Shenzhen) Dennis Lam Eye Hospital, 1 Tairan 9th Rd, Futian, Shenzhen, Guangdong, PRC, Shenzhen, China; 3Shenzhen Polytechnic, Xili Lake, Nanshan District, Shenzhen, Guangdong, PRC, Shenzhen, China; 4Department of Ophthalmology & Visual Sciences, The Chinese University of Hong Kong, 4/F, Hong Kong Eye Hospital, 147K Argyle Street, Kowloon, Hong Kong, HongKong, China; 5Dennis Lam & Partners Eye Center, Suite 1515, Central Building, 1-3 Pedder Street, Central, Hong Kong, HongKong, China.

Purpose: To evaluate mitomycin-C (MMC) aqueous humor concentration after photorefractive keratectomy without epithelial removal (PRK) or Transepithelial PRK (TPRK).

Methods: In this experimental study, thirty eyes of 15 male New Zealand white rabbits (2.5-3kg, 3 months) were divided into 3 groups to correct -3 diopeters (D), -6D, -9D respectively with 6-mm optical zone, each rabbit was randomized undergo PRK without epithelial removal (PRK) in one eye and TPRK on the other. Sponges soaked with 0.02% MMC were applied on the exposed corneal stroma for 120 seconds. Aqueous humor was withdrawn from all rabbit eyes 10 minutes after MMC application and high-performance liquid chromatography was performed to detect and quantify MMC levels. Wilcoxon’s sign rank test and Spearman rank correlation statistical methods were used for statistical analysis.

Results: The mean MMC aqueous humor concentration in groups 1, 2 and 3 were 0.123±0.044 µg/ml, 0.222±0.053 µg/ml, 0.344±0.121 µg/ml respectively for PRK eyes; and 0.412±0.152 µg/ml, 0.431±0.141 µg/ml, 0.660±0.173µg/ml respectively for TPRK eyes. Significant difference was found between PRK and TPRK in each group (p<0.05). Correlation between aqueous MMC concentration and residual cornea thickness were negative in PRK (r=-0.743; p=0.001) and TPRK (r=-0.554; p=0.032). Aqueous concentration of MMC increased linearly with decreased residual cornea thickness.

Conclusions: MMC aqueous humor concentration was correlated negatively with residual cornea thickness. Reserving more residual cornea thickness would be good for reducing the potential MMC toxicity.
Program Number: 5287 Poster Board Number: B0240
Presentation Time: 8:30 AM–10:15 AM
Central flow toric implantable collamer lens implantation
Purpose: To evaluate the outcomes of toric phakic implantable collamer lens (ICL, EVO model) for moderate to high myopic astigmatism.
Methods: Prospective study included 99 eyes of 53 patients who underwent toric ICL V4c. We assessed visual outcomes, refraction, safety, efficacy, predictability, stability, intraocular pressure (IOP), vaulting and endothelial cell density (ECD).
Results: Mean preoperative uncorrected distance visual acuity (UDVA) was 1.5 (logMAR), corrected distance visual acuity (CDVA) was 0.18 (logMAR), mean spherical equivalent (SE) was -11.42 diopters (D). After 2-year follow-up, average UDVA was 0.17, SE was -0.75 D, these changes were statistically significant. CDVA, IOP and vaulting did not show significant differences. Paired T-test was used for statistical analysis.
Conclusions: This study demonstrates remarkable improvement in visual and refractive results with the novel toric ICL (EVO) model in a considerable number of patients during long-term follow-up. UDVA improved from 1.5 logMar to 0.20 logMar after central flow (EVO) ICL implantation. Our results confirm the potential benefits of phakic collamer lens implantation as an effective treatment option in the refractive surgery armamentarium.
Commercial Relationships: Alejandro Navas; Eduardo Martínez-Sánchez, None; Valeria Oliva-Biénzobas, None; Arturo Gómez-Bastar, None; Aida Jimenez-Corona, None; Alejandro Lichtinger, None; Arturo J. Ramirez-Miranda, None; Enrique O. Graue-Hernandez, None

Program Number: 5288 Poster Board Number: B0241
Presentation Time: 8:30 AM–10:15 AM
In vivo confocal laser microscopy of morphologic changes after Small Incision Lenticule Extraction with Accelerated Cross-Linking (SMILE Xtra) in Patients with Thin Corneas and high myopia
yugui zhou, quan liu. zhongshan ophthalmic center, Guangzhou, China.
Purpose: To evaluate the microstructural modifications and safety of small incision lenticule extraction combined with accelerated cross-Linking (SMILE Xtra) in high myopia and thin corneas by means of in-vivo confocal microscopy (IVCM) and 3D-OCT after a 6-month follow-up.
Methods: Forty-three eyes with high myopia and thin corneas were enrolled. All eyes underwent SMILE Xtra. Morphologic modifications of corneal architecture were evaluated prior to SMILE Xtra and 7 days, 1, 3, and 6 months after SMILE by IVCM and 3D-OCT.
Results: The corneal epithelial cells showed slight damage until 3 months postoperatively. The subepithelial nerve plexus decreased but no absence within the treatment zone at the first week after treatment, recolonized at 3 months postoperatively, and had mostly recovered at the 6 months postoperative but remained less than its normal baseline state. Keratocytes were absent in the surgical interface area, and the presence of strong reflective particles and cicatrical reaction in the anterior stroma were observed during the entire 6-month examination period. Increased hyperreflectivity was observed from the cap side at a depth of 60um to stroma bed at a depth of 388um through 6 months. The depth of the demarcation line in 40 eyes (93.0%)was at a mean depth of 296.12±47.86µm (range 211 to 388µm). No particular change between preoperative and postoperative corneal endothelium was observed.
Conclusions: Confocal microscopy showed increased hyperreflectivity in the SMILE Xtra eyes. We confirmed the safety of the SMILE Xtra but recognize that larger and longer term studies of SMILE Xtra are necessary.

Endothelial examined at preoperation (A), 1(B), 3(C), and 6(D) months after treatment. No significant differences were found in cell count or cell morphology between preoperative and postoperative corneal endothelium. HRT image; magnification, 400×400µm

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Corneal lenticular incision procedure has recently become a popular method for refractive vision correction related corneal incisions. This novel technology uses short laser pulsewidth, small focus spot size, and an ultrafast laser beam delivery technology on a standard optical eye model. The analysis is for the worst case: the laser beam is at a fixed location throughout the procedure, and over 50% of laser pulse energy is converted into plasma and does not reach retina. The actual exposure at a given location at retina is estimated to be less than 40% of the worst case scenario.

**Purpose:** To confirm the trajectory thickness control precision, lenticular incision was performed on 8 glass samples: the target and achieved center thicknesses were within the measurement error of ±1µm.

b) The lenticule incisions using 70nJ pulse energy and 28s cutting were performed on 50 pig eyes: the lenticule can be removed easily without the need to separate the two cutting surfaces prior to the removal.

c) An optimized algorithm with reduced pulse overlap showed with 5 pig eyes that the lenticular incision with the same easiness of lenticule removal can be done within 15s without degradation of thickness or bed depth consistency.

d) It is shown with 5 pig eyes that the pulse energy can be as low as 40nJ to dissect tissue-bridge free lenticule without degradation of thickness or bed depth consistency.

**Conclusions:** We have shown that the novel ultrashort femtosecond laser technology with ultrafast scanning is capable to perform tissue-bridge free lenticule incisions at 70nJ pulse energy and within 15s. This technology has the potential to perform wavefront guided lenticule incision with iris registration. We plan to evaluate this technology for cadaver eyes in the near future.

**Commercial Relationships:** Alireza Malek Tabrizi, Abbott Medical Optics (E); James E. Hill, Abbott Medical Optics (E); Nima Khatibzadeh, Abbott Medical Optics (E); Saeed Taheri, Abbott Medical Optics (E); Hong Fu, Abbott Medical Optics (E)

**Program Number:** 5290  **Poster Board Number:** B0243  **Presentation Time:** 8:30 AM–10:15 AM

**A Novel Ultrashort Femtosecond Laser with Ultrafast Scanner for Corneal Lenticule Surgery**

**A Novel Ultrashort Femtosecond Laser with Ultrafast Scanner for Corneal Lenticule Surgery**

**Alireza Malek Tabrizi, James E. Hill, Nima Khatibzadeh, Saeed Taheri, Hong Fu. R&D, Abbott Medical Optics, Milpitas, CA.**

**Purpose:** Corneal lenticular incision procedure has recently become an alternative refractive vision correction procedure. To improve the precision of lenticular geometry by minimizing residual tissue bridge in the lenticule dissection, improving centration, and reducing suction break rate, we evaluated a novel ultrashort femtosecond laser with shorter pulsewidth, tighter focus, high pulse reprate, and ultrafast scanning. The purpose of this poster is to describe the ultrafast scanning mechanism and present preliminary lenticule incision results on ex-vivo pig eyes.

**Methods:** The ultrafast scanning mechanism is capable to: a) Scan a 10 MHz laser pulse train into a densely packed cutting pattern of about 1µm x 1µm spot separation, which is the key to minimize residual tissue bridges. b) Cut curved lenticular surfaces with submicron thickness control in the cutting trajectory, which is the key to improve refractive correction accuracy. c) Cut angled entry cuts. d) Reserve laser beam quality to achieve diffraction-limited focal spot during ultrafast scanning. This scanning mechanism consists of 6 synchronized motors: an ultrafast 8 kHz resonant scanner, a scan line rotator, a slow-z motor, a fast-z motor, X and Y linear motors.

**Results:** a) To confirm the trajectory thickness control precision, lenticular incision was performed on 8 glass samples: the target and achieved center thicknesses were within the measurement error of ±1µm.

b) The lenticule incisions using 70nJ pulse energy and 28s cutting were performed on 50 pig eyes: the lenticule can be removed easily without the need to separate the two cutting surfaces prior to the removal.

c) An optimized algorithm with reduced pulse overlap showed with 5 pig eyes that the lenticular incision with the same easiness of lenticule removal can be done within 15s without degradation of thickness or bed depth consistency.

d) It is shown with 5 pig eyes that the pulse energy can be as low as 40nJ to dissect tissue-bridge free lenticule without degradation of thickness or bed depth consistency.

**Conclusions:** We have shown that the novel ultrashort femtosecond laser technology with ultrafast scanning is capable to perform tissue-bridge free lenticule incisions at 70nJ pulse energy and within 15s. This technology has the potential to perform wavefront guided lenticule incision with iris registration. We plan to evaluate this technology for cadaver eyes in the near future.

**Commercial Relationships:** Alireza Malek Tabrizi, Abbott Medical Optics (E); James E. Hill, Abbott Medical Optics (E); Nima Khatibzadeh, Abbott Medical Optics (E); Saeed Taheri, Abbott Medical Optics (E); Hong Fu, Abbott Medical Optics (E)
Conclusions: Based on the IEC guidelines for MPE at retina, the maximum allowed pulse energy is given by \( E_{\text{max}} \leq 418t^{2} \text{nJ/pulse} \). The retinal exposure in flap and lenticule incision procedures is \( \leq 40\% \) of MPE in the worst case scenario, i.e., it has a \( \geq 60\% \) safety margin.

Commercial Relationships: Zheng Sun, Abbott Medical Optics Inc. (E); Hong Fu, Abbott Medical Optics Inc (E)

Program Number: 5291 Poster Board Number: B0244
Presentation Time: 8:30 AM–10:15 AM
Fiber Beam Delivery for Novel Ultrashort Femtosecond Laser Technologies
Vladimir G. Lemberg, Saidur Rahaman, Nima Khatibzadeh, Alireza Malek Tabrizi, Hong Fu. Advanced R&D, Abbott Medical Optics, Santa Clara, CA; Abbott Medical Optics, Milpitas, CA.

Purpose: Femtosecond lasers are widely used for various ophthalmic applications ranging from creating flaps in LASIK procedures, corneal lenticule incisions, creating pockets for the corneal inlays to cataract surgery. The use of conventional optical fiber laser beam delivery is a common and convenient way to deliver the laser energy to the target tissue. However, the uses of conventional fiber based beam delivery for ultrashort laser pulses are limited due to the optical fibers dispersion. The recent advances in development of the hollow-core photonic crystal fibers opened up new opportunities to build a flexible beam delivery configuration for novel femtosecond laser technologies.

Methods: The femtosecond laser (pulsewidth 100-200fs) was coupled into Kagome hollow-core photonic crystal fiber PM-C-Yb-7C. We matched the laser beam waist to fiber mode field diameter and the numerical aperture of the fiber, using variable NA optical system to achieve the high coupling efficiency. The low NA fiber output beam was re-collimated and delivered to the scanning and high numerical aperture (NA 0.6) focusing system. We attempted to create variety of the corneal cuts, using the flexible delivery configuration.

Results: By using the variable NA optical system we have achieved the high (more than 94%) coupling efficiency and low (less than 2.5%) transmission losses (attenuation of -0.05 dB per meter at 1030 nm). Due to close to zero dispersion (~1 fs/nm/meter) at 1030 nm wavelength the femtosecond laser pulses were transmitted with virtually no pulse width broadening. Particular attention was given to the study the mechanical stability in the axial and radial directions as well as the beam quality and transmission losses as a function of the fiber bending radius. The high quality of the re-collimated beam, the high coupling efficiency and low transmission losses allowed us to demonstrate variety of corneal cuts ranging from flap, intrastromal lenticule and keratoplasty incisions and inlay pockets.

Conclusions: Our study demonstrated that the recent advances in development of the hollow-core photonic crystal fibers (zero dispersion at the design wavelength, absence of Fresnel reflections from the fiber-end faces high damage threshold and low transmission and bend losses) opened up new opportunities to build flexible beam delivery configuration for novel femtosecond laser technologies.

Commercial Relationships: Vladimir G. Lemberg, Abbott Medical Optics (E); Saidur Rahaman, Abbott Medical Optics (E); Nima Khatibzadeh, Abbott Medical Optics (E); Alireza Malek Tabrizi, Abbott Medical Optics (E); Hong Fu, Abbott Medical Optics (E)

Program Number: 5292 Poster Board Number: B0245
Presentation Time: 8:30 AM–10:15 AM
Laser Tissue Evaluation for a Novel Ultrashort Femtosecond Laser with Auto-Z Calibration
Nima Khatibzadeh, Alireza Malek Tabrizi, James E. Hill, Saidur Rahaman, Zenon Witowski, Zheng Sun, Saeed Taheri, Hong Fu. Abbott Medical Optics, San Jose, CA.

Purpose: Femtosecond laser has been used for creating LASIK flap, inlay channel, and other corneal incisions. To further advance the femtosecond technology, we evaluated a novel ultrashort femtosecond laser. The purpose here is to present the experimental results for flap and inlay channel incisions.

Methods: The novel ultrashort femtosecond laser was built with an ultrashort fiber laser, a high numerical aperture beam delivery, and an ultrafast scanning. The cutting depth is controlled with sub-micron precision using an innovative automatic glass interface detection device (Auto-Z). Over 200 ex-vivo pig eyes were used in the evaluation.

Results: 1-Flap thickness consistency: 9mm diameter flap with a targeted thickness of 80µm was performed on 50 pig eyes, with side cut energy=110nJ/pulse, bed cut energy=70nJ/pulse, and the cutting time was 8.7s. All flaps showed tissue-bridge free dissection and easy lift as evaluated by subject matter experts (SME). The achieved average thickness=81µm, the standard deviation=1.9µm compared to 5–12µm for on-market products. 2-Flap cutting time: by increasing bed cut energy to 90nJ/pulse and accelerating scanning speed, 5.0 s cutting time was achieved. Tissue roughness of the flap was measured using a white light interferometer: mean roughness=1.6±0.7µm, RMS roughness=2.0±0.9µm (N=8), comparing to mean=2.6µm and RMS=3.2µm of a control flap cut with iFS Advanced Femtosecond Laser. 3-Flap bubble releasing: to ensure there is always a gas escape channel, the flap incision starts with the side cut, then a ring bed cut underneath the side cut, then the bed cut. Random gas bursts from the side cut was observed in flap incisions; no gas buildup inside the flap was observed (N=10). 4-Inlay channel: both standard and lollipop inlay channel patterns on pig eyes demonstrated uniform bubble patterns and ease of insertion for the Inlay disk with no significant adhesion judged by SME. Placement depth of the Inlay disk measured by an OCT was ±6µm of the intended depth of 200µm (N=10).

Conclusions: We have shown with preliminary pig eye results that the novel ultrashort femtosecond laser can create tissue-bridge free flap incisions and Inlay channels with superior thickness consistency, smooth tissue dissection, no gas buildup, and shortened cutting time. We plan to perform further experiments on cadaver eyes.

Commercial Relationships: Nima Khatibzadeh, Abbott Medical Optics (E); Alireza Malek Tabrizi, Abbott Medical Optics (E); James E. Hill, Abbott Medical Optics (E); Saidur Rahaman, Abbott Medical Optics (E); Zenon Witowski, Abbott Medical Optics (E); Zheng Sun, Abbott Medical Optics (E); Saeed Taheri, Abbott Medical Optics (E); Hong Fu, Abbott Medical Optics (E)
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**Mechanism:** The mechanism is provided by the plasma-induced micro-cavitation bubble. The fundamental limit for cutting precision and cutting quality is determined by two critical parameters: the laser pulsewidth and the focus spot size. Shorter pulsewidth and smaller focus spot will result in more precise dissection and less collateral tissue disturbance. The purpose of this poster is to present characterization results for a novel ultrashort femtosecond laser that uses a very short pulsewidth and smallest spot size.

**Methods:** Experimental setup was built with a femtosecond fiber laser, a high numerical-aperture beam delivery, and an ultrafast scanning module. To achieve the shortest pulsewidth at the cut point, the laser is pre-compensated for the pulse broadening introduced by the group-velocity dispersion of the beam delivery optics. The effect of pulsewidth on tissue dissection was evaluated based on incisions on pig eyes. The laser pulsewidth at the focus was characterized with a Frequency-Resolved-Optical-Gate instrument. The focus spot size in water was measured with a customized water immersed spot size camera.

**Results:**
a) The effect of pulsewidth on tissue dissections on pig eyes was evaluated with 2 different types of fiber lasers and 1 free-space laser, and for a given fiber laser with different pulsewidth settings. It was observed that that there is a small but definitive difference in both flap creation and lenticule incision: a laser with 100-200fs pulsewidth produces easier flap lift and lenticule removal than that with pulsewidth ≥250fs. 
b) The pulsewidth at the focus of 8 femtosecond fiber lasers were measured: they are all within the target range of 100 fs to 200 fs, confirming the effectiveness of the pre-compensation mechanism.

c) The focus spot sizes in the surgical volume for 5 such setups were measured: the 50%-energy spot diameters are all well below 1.3 µm, achieving the design target for the diffraction-limited beam delivery optics.

**Conclusions:** We have characterized a novel ultrashort femtosecond laser that uses a shorter pulsewidth and smallest focus spot size compared with ophthalmic femtosecond lasers on the market. The preliminary cutting results show that this novel technology has the potential to produce more precise and tissue-bridge free corneal incisions.

**Commercial Relationships:** ZENON WITOWSKI, Abbott Medical Optics Inc (E); Saidur Rahman, Abbott Medical Optics Inc (E); Zheng Sun, Abbott Medical Optics Inc (E); Alireza Malek Tabrizi, Abbott Medical Optics Inc (E); James E. Hill, Abbott Medical Optics Inc (E); Hong Fu, Abbott Medical Optics Inc (E)

**Program Number:** 5294 **Poster Board Number:** B0247 **Presentation Time:** 8:30 AM–10:15 AM **Comparison of wavefront-guided and wavefront-optimized refractive surgeries for astigmatism of 0.75 diopters or less**

**Purpose:** To compare the refractive outcomes of wavefront-guided (WFG) and wavefront-optimized (WFO) refractive surgeries in myopic eyes with low refractive cylinder.

**Methods:** The study comprised of subjects electing to undergo either photorefractive keratectomy (PRK) or laser-assisted in situ keratomileusis (LASIK) for myopic astigmatism. Each subject was randomly assigned to either WFG or WFO treatment. WFG surgeries were performed using the VISX CustomVue STAR S4 IR (Abbott Medical Optics) whereas WFO surgeries were done using WaveTec Allegretto Wave EyeQ (Alcon Surgical). The refractive target was emmetropia in all eyes. Data analysis included eyes with preoperative refractive cylinder of 0.75 D or less were analyzed. The mean preoperative refractive sphere was -3.39 D ± 1.60 for WFG and -3.20 D ± 1.52 for WFO group (p=0.36); the cylinder was -0.50 D ± 0.19 for WFG and -0.50 D ± 0.20 for WFO group (p=0.93). At 6 months postoperatively, 99.0% of WFG eyes vs. 98.3% WFO eyes achieved uncorrected distance visual acuity (UDVA) of 20/20 or better (p=0.99); 77.8% of WFG vs. 76.7% of WFO eyes had UDVA of 20/15 or better (p=0.87); 94.9% of WFG eyes vs. 93.5% of WFO eyes had uncorrected spherical equivalent within ±0.50 D of emmetropia (p=0.25); and 93.9% of WFG vs. 90.8% of WFO eyes had (non-vector) refractive cylinder ≤0.50 D (p=0.45). The mean magnitude of error was 0.01 D ± 0.20 for WFG and 0.13 D ± 0.25 for WFO group (p=0.001). The applied treatment was within 15 degrees of the intended treatment axis in 70.7% of WFG eyes and 74.2% of WFO eyes (p=0.65). The correction index (surgically induced astigmatism/target induced astigmatism) was 1.06 for WFG and 1.39 for WFO treatment (p<0.001).

**Conclusions:** In myopic eyes with ≤0.75 D of astigmatism, WFO-treated eyes tended to be overcorrected compared to WFG-treated eyes. This notwithstanding, both laser platforms were effective and comparable in achieving excellent visual acuities postoperatively.

**Commercial Relationships:** Bruce Rivers, None; Rose K. Sia, None; Denise S. Ryan, None; Richard D. Stutzman, None; Joseph F. Pasternak, None; Lamarr Peppers, None; Lorie Logan, None; Jennifer B. Eaddy, None; Kraig S. Bower, None

**Support:** W81XWH-09-2-0018

**Clinical Trial:** NCT01097525

**Program Number:** 5295 **Poster Board Number:** B0248 **Presentation Time:** 8:30 AM–10:15 AM **Thinning of corneal grafts with excimer laser for posterior lamellar keratoplasty – where are the limits?**

**Purpose:** The ultrathin DSAEK methods have superior visual results comparing to conventional DSAEK. We have newly introduced an ultrathin DSAEK technique of corneal graft thinning and smoothing using excimer laser (Microkeratome and Excimer Laser assisted Endothelial Keratoplasty - MELEK), which showed good clinical results. The described group of ultrathin graft lamellas had the mean thickness above 100 µm and no damage of endothelial cells after laser treatment was reported. In this experimental study we wanted to proof the possibilities and limitations of the further graft thinning respecting endothelial damage and graft thickness.

**Methods:** Ten experimental human donor corneas, not suitable for the transplantation, were prepared by a single cut of a microkeratome (Moria, 350 µm) and mounted on an artificial anterior chamber. Afterwards they were smoothed and thinned with an excimer laser (Esiris, Schwind) using an ablation profile of phototherapeutic...
The thinning and smoothing of the corneal grafts to the thickness of 40 µm is predictable and safe. The lamella below 30 µm shows a greater risk of perforation. The treatment of the corneal grafts with excimer laser does not influence the endothelial cell count.

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