3rd International Congress of Wavefront Sensing and Aberration-Free Refractive Correction

and

Short course in ophthalmic wavefront sensing and wavefront-guided corneal laser surgery

Casino Kursaal

Interlaken, Switzerland

February 15th – 17th, 2002

Dear Colleagues,

It is our pleasure to welcome you to the Casino Kursaal in Interlaken, Switzerland for the **3rd International Congress on Wavefront Sensing and Aberration-Free Refractive Correction**.

The meeting provides an exciting program related to the latest topics in wavefront representation, biomechanical changes of the cornea, laser technologies, and physiological optics. During this congress we will address the most important problems in corneal laser surgery and discuss the current commercial techniques available for customized ablations. More than 20 invited speakers make this congress the premier world-class interactive forum devoted to ocular wavefront sensing and aberration-free refractive correction.

For the first time, the **International Congress on Wavefront Sensing and Aberration-Free Refractive Correction** has accepted free-papers and poster presentations. During the congress more than 50 authors involved in current research activities or clinical trails in fields that are related to the topics of the wavefront congress present their latest results.

For those of you who are interested in becoming more proficient in the area, or want to take a refresher course on wavefront sensing, design, and implementation of aberration-free refractive corrections will have the opportunity to participate in our excellent **short course in ophthalmic wavefront sensing and wavefront-guided corneal laser surgery**. This 1½ day short-course will be taught by world leaders in these areas.

The organizers would like to thank our sponsors for their active participation and for supporting the 2002 wavefront congress.

We wish you a pleasant stay in Interlaken during the **3rd International Congress on Wavefront Sensing and Aberration-Free Refractive Correction**.

Sincerely,

Michael Mrochen   Raymond A. Applegate
Ron Krueger   Theo Seiler

Table of Contents

Congress Information

Organising Committee:

Local Organizer
Michael C. Mrochen, PhD, University of Zurich

Scientific Committee:

Raymond A. Applegate, OD, PhD
University of Texas

Ronald R. Krueger, MD, MSE
Cole Eye Institute

Michael C. Mrochen, PhD
University of Zurich

Theo Seiler, MD, PhD
University of Zurich

General Information

Congress Management
CBS Congress & Business Services
Technoparkstrasse 1
CH-8005 Zurich
Switzerland

Phone	+41 –1 445 34 50
Fax.	+41 –1 445 34 55
E-Mail:	cbs-congress@active.ch

Emergency Numbers
Phone and fax numbers during the congress (Registration-Desk)

Phone:	+41-33-827 62 30
Fax:	+41-33-827 62 31

Coffee break
Morning and afternoon coffee break will be served in the exhibition area and are offered during the Scientific Sessions.

Exhibition
Exhibits of the latest technical equipment will take place at the Congress Venue.

Lunches
Lunches will be served in the exhibition area and are included in the registration fee.

Name badges / Important Note
Please wear the individual name badge permanently and well visible during the entire congress including social functions.

Certificate of Attendance
Each participant of the congress will receive a certificate of attendance.

Smoking Rules
Smoking is not allowed during sessions, meetings and presentations.

Mobile Communication
Participants are kindly ask to refrain from using mobile phones during sessions, meetings and presentations.

Hotel Accounts
All delegates are reminded to pay their hotel account prior to departure. In case of a deposit paid, this deposit will be deducted from the final bill. The hotel takes the right to charge for later arrival or non-arrival.

Shopping
Switzerland's superb range of products make it a shopper's paradise. Excellent buys are watches, pocket knives, textiles, woodcarving, music boxes, embroideries, fine hankerchiefs, other handmade items and of course Cuckoo clocks.

Shops are generally open from 09:00 am to 06:30 pm weekdays, 09:00 am to 04:00 pm Saturdays; closed Sundays.

Banking Hours
Banks' opening hours are generally Monday to Friday from 08:30 am to 04:30 pm. They are closed Saturday and Sunday. However, most banks provide a 24-hour banking cash service. Exchange facilities are available at the airport, major hotels and railway stations.

Tips
Tips are always included in the prices displayed.

On-site Registration and Assistance

On-site registration during the congress is possible. Payment modalities include cash (Swiss Francs only) and the following creditcards: Visa, Mastercard. A team of multilingual assistants is ready to help in case of any problems you may encounter on site. At the Registration/Hospitality Desk guests will also be given general information on tourism, advice and support on planning an outing, an excursion or a tour.

Registration Desk
The Registration/Hospitality Desk will be open as follows:

Thursday, February 14, 2002	07:00 am to noon (only for short course)
Friday, February 15, 2002	08:00 am to 8:00 pm
Saturday, February 16, 2002	07:00 am to 6:00 pm
Sunday, February 17, 2002	07:30 am to 3:00 pm

On-site Registration Fees

ISRS /Member*	CHF 770.00
AAOptom Members*	CHF 770.00
Non-members	CHF 910.00
Accompanying person	CHF 260.00

Registration for short course
(February 14-15, 2002) **

ISRS Member*	CHF 520.00
AAOptom Member*	CHF 520.00
Non-members	CHF 610.00

* ISRS and AAOptometry membership number required. ** The maximum number of participants is limited to 100 persons.

Participation's Registration Fee includes:
-Attend all Meeting sessions
-Welcome Cocktail (February 15, 2002)
-Terrific Tell Dinner (February 16, 2002)
-Lunch on February 16, 17
-Refreshments during coffee breaks
-Entry to Exhibition area
-Entry to Poster Display

Accompanying Person's registration Fee includes:
-Welcome Cocktail (February 15, 2002)
-Guided city tour to the Swiss capitol Berne (February 16, 2002)
-Terrific Tell Dinner (February 16, 2002)

Cancellations
The following rules apply to cancellations:
Through November 30, 2001: Refund of total amount paid minus CHF 100.00 per registration to cover administration costs. *From November 30, 2001 to January 15, 2002*: Refund of total amount paid minus 50%. *After January 15, 2002*: No refunds will be possible. Refunds will be calculated based on the date by which CBS Congress & Business Services receives written cancellation notice (fax or letter).

General remark

The participant acknowledges that he/she has no right to lodge damage claims against the organizers should the holding of the meeting be hindered or prevented by unexpected political or economic events or generally by a higher force (circumstances beyond our control), or should the non-appearance of speakers or other reasons necessitate program changes. With registration, the participants accepts this proviso.

Short course in ophthalmic wavefront sensing and wavefront-guided corneal laser surgery

Thursday, February 14th, 2002

7:00 am to 8:00 am	**Registration for short course and wavefront meeting**
8:00 am to 9:00 am	*A review in optics* Austin Roorda
9:00 am to 10:00 am	*Representation of wavefront aberrations* Larry Thibos
10:00 am to 10:45 am	***Coffee break***
10:45 am to 11:45pm	*Wavefront sensing technologies* Ronald R. Krueger
12:00 pm to 1:00 pm	***Lunch***
1:00 pm to 2:00 pm	*Converting wavefronts into corrections* *Part I: Laser tissue-interaction* Michael C. Mrochen
2:00 pm to 3:00 pm	*Converting wavefronts into corrections* *Part II: Optical assumptions* Pablo Artal
3:00 pm to 3:45 pm	***Coffee break***
3:45 pm to 4:45 pm	*Aberrations and visual performance.* *Part I: Optical and Neural Limits to Vision* Raymond Applegate
4:45 pm to 5:45 pm	*Aberrations and visual performance.* *Part II: Optical Aberrations* Susana Marcos

Friday, February 15th, 2002

9:00 am to 10:00 am	*Technical and clinical aspects of adaptive optics* Geunyoung Yoon
10:00 am to 11:00 am	*Ask the question you always wanted to ask ?* Final discussion with all short course speakers !

3rd International Congress of Wavefront Sensing and Aberration-Free Refractive Correction

Friday, February 15th, 2002

3:00 pm to 7:00 pm	Industry Exhibition
3:00 pm to 6:00 pm	Poster Session
6:00 pm to 8:00 pm	Welcome cocktail

Poster Session I: Wavefront Sensing Techniques

Ignacio Iglesias	*Extended-Source Pyramidic Wavefront Sensor for the Eye*
Johannes Pfund	*Shack-Hartmann sensor for detection of extremely curved wave fronts*
Jonathan Brooks	*A Portable Wavefront Sensor to Measure Ocular Aberrations*
Hartmut Vogelsang	*Important facts of ocular wave front measurements with Shack-Hartmann sensor based Systems*
Daniel M. Topa	*Exact computation of Zernike amplitudes over a reduced pupil diameters*
Daniel M. Topa	*Computing with Taylor polynomials in lieu of Zernike polynomials*
Daniel M. Topa	*The number of lenslets and the precision of the Zernike amplitudes*
Daniel Marks	*Demonstration of Sampling Field Sensor Surface Measurement*
Daniel M. Topa	*A reconstructor for ophthalmic wavefront sensing*

Poster Session II: Clinical Wavefront Sensing

Andrew Carkeet	*Effects of Race and Refractive error on Corneal Aberrations and Whole-Eye Aberrations in Singaporean School Children.*
Thomas Salmon	*Accuracy, repeatability and instrument myopia with COAS Shack-Hartmann Aberrometer*
Daniel Durrie	*Evaluation of a scanning-slit aberrometer (Nidek OPD Scan) and a Shack-Hartmann aberrometer (Wavefront Sciences COAS Wavefront Analyzer)*
Marine Gobbe	*Corneal aberrations – measurement repeatability*
Douglas Koch	*Reliability and Accuracy of The VISX WaveScan Aberrometer in higher and lower order aberrations*

Rossen Hazarbassanov	*Comparison of Pre- and Post-LASIK high order aberrations measured at various optic zones*
Joseph Miller	*Spherical Aberration in Normal, Dilated, IOL and LASIK Patients*
Arthur Cummings	*Consistency of higher order Aberrations with the WaveLight Tscherning Aberrometer*
Daniel R. Neal	*Temporal dynamics of vision: Analysis of aberrations using a Shack-Hartmann aberrometer*
Tomy Starck	*Does increased negative spherical aberration or a slight myopic residual correction explain multifocality after hyperopic LASIK*

Poster Session III: Wavefront corrections

Werner Förster	*A model for testing the correction of optical aberrations*
Austin Roorda	*Adaptive Optics Scanning Laser Ophthalmoscope*
Frieder Loesel	*Adaptive Optics: Real-time compensation of visual aberrations with the VISX WaveScan 2*

Poster Session IV: Others

Isaac Lipshitz	*30 Reasons why we cannot achieve super vision using only Excimer laser.*
Jose Ramon Jimenez	*Equation for corneal asphericity after refractive surgery*
Hans-Henner Becker	*Flying spot versus fractal moved mask system: Investigation of the keratocyte vitality after excimer laser ablation (193nm)*
Frieder Loesel	*Flap Creation with a Ultrashort Pulse Intrastromal Laser Microkeratome*
Sandra Franco	*Measuring corneal pachymetry with a rotary scanning system*
Daniel M. Topa	*Finding the center of the pupil and the fidelity of the Zernike amplitudes*
Mirko Jankov	*Experimental results on preparing laser-shaped stromal implants for Laser-assisted intrastromal keratophakia (LAIK) in extreme complicated LASIK cases*
Mauro Campos	*Initial Experience in Adjusting the LadarVision Excimer Laser Nomogram*
Achim Langenbucher	*Wavelet analysis for detection of corneal irregularities after PRK*

Welcome cocktail

6:00 pm to 8:00 pm *Welcome cocktail, poster session and industry exhibition.*
All participants and accompanying persons will be welcomed with drinks and snacks at the Kursaal Casino Interlaken. This reception promises to be a delightful prelude to the congress itself.

Saturday, February 16th, 2002

8:00 am to 6:00 pm	Industry Exhibition
8:00 am to 6:00 pm	Poster Session
8:00 am to 6:00 pm	Sessions
6:30 pm to 12:00 am	Wilhelm Tell Dinner

Session I: Standards

08:00 am	*Introduction on wavefront data representation* Raymond Applegate
08:12 am	*Standards for displaying wavefront maps and errors* Edwin Sarver

Session II: Biomechanics and optic

08:24 am	*Biomechanics of the cornea* Cynthia Roberts
08:36 am	*Non-invasive measurement of the Mechanical Properties of the Cornea* Mardi Hastings
08:48 am	*Finite Element Model of Corneal Response to Laser Refractive Surgery* Noriko Katsube
09:00 am	*Flap induced changes in the wave aberration in LASIK* Jason Porter
09:12 am	*Flap induced changes in the wave aberration in LASIK* Sofia Panagopolou

Coffee break

9:25 am to 10:00 am	*Coffee break and industry exhibition*

Session III: Non excimer laser technologies

10:00 am	*Biomaterials for corneal inlays* Jean-Marie Parell
10:12 am	*Laser thermo keratoplastic* Ronald R. Krueger
10:24 am	*Femtosecond laser* Holger Lubatschowski

Session IV: Excimer laser platforms

10:36 am	*UV Photoablation -What is unknown ?* Fabrice Manns
10:48 am	*Centration - How accurate is accurate ?* Michael Bueeler

11:00 am	*Eye movements - How fast is fast ?* Nathalie Taylor
11:12 am	*Wavefront and Topography - Do we need both ?* Jim Schwingerling

Lunch

11:25 am to 1:00 pm	*Lunch and industry exhibition.*

Session V: Ocular wavefront aberrations

1:00 pm	*Are all aberrations equal ?* Raymond Applegate
1:12 pm	*Single number metrics for quantifying ocular aberrations.* Larry Thibos
1:24 pm	*Importance of chromatic aberrations* Pier Giorgio Gobbi
1:36 pm	*Are Optical aberrations during accommodation a significant problem for refractive surgery* Pablo Artal
1:48 pm	*Are Optical aberrations as a function of age a significant problem for refractive surgery* Susana Marcos
2:00 pm	*Total wavefront and corneal aberrations* Michael Mrochen

Session VI: Current problems in customized treatments

2:12 pm to 2:45 pm	*Rate the 10 most important problems in customized treatments.* **Presenter:** Theo Seiler

The top ten lists of various clinicians and researchers were sampled and summarized to a list of 15 very important problems in customized treatments. Each problem is introduced to the ordinance and rated by a jury of experts.

Jury members:

Steve Brint	Athur Cummings
Thomas Kohnen	Douglas Koch
Ronald R. Krueger	Scot MacRae
Iannins Pallikaris	Dan Reinstein
Steven Trokel	Georg Waring

Coffee break

2:45 pm to 3:15 pm	*Coffee break and industry exhibition*

Session VII: Commercial perspective

3.15 pm to 4:45 **"Revealing Company Secrets"**
Please tell the truth nothing but the truth !

How my Company answers the following 6 questions:

1. How does your company determine the accuracy and precision with which your wavefront device determines sphere, cylinder, and axis as well as the higher order aberrations ? What method do you provide for the clinician or investigator to calibrate your wavefront device ?
2. Under what conditions does your company recommend the wavefront measurement be performed? In your answer, specify:
   a. Whether the eye is dilated and if so how ?
   b. What is the procedure used to center the measurements ?
   c. How many measurements are taken ?
   d. Are the measurements averaged or is a best measurement selected, and if so, how?

   What is the status of accommodation during the measurement ?
3. How does your company standardize the report of the wavefront measurement? If different from the reporting schemes recommended by the OSA task force, explain why ?
4. How does your company compensate for biomechanical corneal responses ?
5. How does your company compensate for variations in the angle of incidence as a function of corneal ablation location ?
6. Does your company believe it is necessary to ablate the actual pattern for each patient in a test surface? If so,
   a. Which Zernike modes are included ?
   b. Are these the same modes to be ablated onto the cornea ?
   c. What is the test surface made of ?
   d. Is the unablated test surface curved similar to the unablated cornea?
   e. Is the test surface objectively verified after test ablation (using the company wavefront sensor or some other objective device)?
   f. How does your company correct for the difference between the test material and corneal tissue?

Corporate Witnesses:
1) Visx; Frieder Loesel
2) Alcon; Gerorg Pettit
3) Asclepion Meditec; Hartmut Vogelsang
4) Bausch and Lomb; Rupert Veith
5) Nidek; Phillip M. Buscemi
6) Schwind; Stefan Pieger
7) WaveLight; Matthias Glasmacher

Cross-examining Attorneys:
1) Raymond Applegate
2) Pablo Artal
3) Ronald R. Krueger
4) Scott MacRae
5) Fabrice Manns
6) Susana Marcos
7) Michael Mrochen
8) Austin Roorda
9) James Schwiegerling
10) Larry Thibos

Twenty slides maximum, speaking time 10 min / Witness. After presentation by the Corporate Witness, the "Cross-examine Attorney" will have 1 minute to ask 1 question of one Witness and each Witness will have 1 minute to respond. Audience will have 15 minutes to question the Witnesses or the Cross-examine Attorneys

Session VIII: Clinical results of customized ablations

Founder's level sponsors

4:45 pm	*Alcon / Summit / Autonomous*	Steve Brint
4:57 pm	*Bausch and Lomb*	Thomas Kohnen, Ian Cox
5:09 pm	*WaveLight Laser Technologie*	Athur Cummings

Associate's level sponsor

5:21 pm	*Visx*	Douglas Koch

Assistance's level sponsors

5:30 pm	*Asclepion Meditec*	Dan Reinstein
5:37 pm	*Nidek*	Richard Bains
5:44 pm	*Schwind eye-tech-solution*	To be announced
5:51 pm	*Tracey*	Vasyl Molebny

Wilhelm Tell Dinner

6:30 pm to 12:00 am *Exiting "Wilhelm Tell Dinner"*

All participants and accompanying persons registered are invited to join us on this occasion to make it an especially memorable evening. Bus transportation and the dinner are included in the registration fee. The busses leave at the entrance of Casino Kursaal conference center.

Sunday, February 17th, 2002

8:00 am to 1:30 pm **Industry Exhibition**

8:00 am to 1:30 pm **Poster Session**

8:00 am to 3:00 pm **Sessions (free papers)**

Session IX: Optical aberrations and vision (free papers)

8:00 am *The effect of aging on scattering and higher-order aberrations*
Kuroda Teruhito

8:10 am *Wavelength dependence of the zernike expansion of the wavefront error in human eyes*
Rejean Munger

8:20 am *The Quality of Vision and Wavefront Aberrations after LASIK*
Steven Schallhorn

8:30 am *Physiological aspects of vision evaluation*
Mykola Sergienko

Session X: Accommodation and IOL's (free papers)

8:40 am *Dynamic wavefront measurements of eyes with accommodative IOL*
H. Burkhard Dick

8:50 am *Aberrations generation by contact lenses with aspheric and asymmetrical surfaces*
Norberto López-Gil

9:00 am *Correcting on-eye and off-eye spherical aberration in soft contact lenses*
Holger Dietze

9:10 am *Dynamic Wavefront Refractometry with Asclepion Aberrometer in different light conditions*
Sophia I. Panagopoulou

9:20 am *Dynamic Wavefront Refractometry with Asclepion Aberrometer in the Accommodation process*
Ioannis G. Pallikaris

Coffee break

9:30 am to 10:00 am *Coffee break and industry exhibition*

Session XI: Adaptive optics and applications in eye care

10:00 am *Extending the limits of seeing the structure of the retina*
Fred Fritzke

10:25 am *Wavefront corrector technologies for ophthalmic adaptive optics*
Scot Oliver

10:50 am *Wavefront-technology and adaptive optics: The Heidelberg Approach*
Josef Bille

11:03 am *Adaptive optics visual simulator*
Pablo Artal

11:16 am *Deconvolution of Adaptive Optics Retinal Images*
Julian C. Christou

11:29 am *Vision Performance Testing with the Lawrence Livermore Adaptive Optics System*
Charles Thompson

Lunch

11:45 am to 1:00 pm *Lunch and industry exhibition.*

Session XII: Basics of Customized treatments (free papers)

1:00 pm *Epithelial and Biomechanical Considerations May Be Required for Accurate Wavefront Guided Ablations*
Dan Z Reinstein

1:10 pm *Wide-field compensation of monochromatic eye aberrations: design trade-offs and performance limits*
Salvador Bará

1:20 pm *Can ocular cyclopositional change between erect and supine body position affect the outcome of aberration-free refractive correction?*
Hermann Dieter Schworm

1:30 pm *Effect of corneal decentration on the outcome of laser refractive surgery procedure*
Geunyoung Yoon

1:40 pm *Limitations of wavefront-corrections with a scanning spot laser system.*
Maik Kaemmerer

1:50 pm *ICT - Intraoperative Corneal Topography for image registration purposes*
Stephan Schruender

Session XII: Clinical results of customized treatments (free papers)

2:00 pm Correction Of higher Order Aberrations By Active Pupil Control.
Isaac Lipshitz

2:10 pm The Reduction of Spherical Aberration with the Wavelight Allegretto
Jeffery Machat

2:20 pm Lasek and Lasik comparative wavefront aberrometry results in myopia and hyperopia with and without astigmatism
Daniel Durrie

2:30 pm Wavefront-guided ablation with MEL 70
Klaus Ditzen

2:40 pm Results of wavefront guided Lasik with the WaveLight Allegretto Wave excimer laser
Arthur Cummings

2:50 pm Allegretto Wavefront Guided LASIK - 3 Month Results
Matthias Maus

3:00 pm End of program

Instructions for authors

Duration of Presentations

Authors must strictly adhere to the time assigned to their presentations in order to avoid the unpleasant event of being interrupted by the moderator. Moderators will exert their authority to keep the busy program running on the schedule. The languages for presentation must be English.

Slide Preview Room

Single and double projection facilities for 36 mm (carrousel) will be available at the Slide Preview room (Ground Floor). Please follow the signs. Presenters must turn in their slides to the projectionist in the preview room **60 minutes** prior to the opening of the session at which they will present.

Presentation by Beamer

IMPORTANT: Please check your laptop with our audio visual technician in the slide preview room for the duration of the session at which they will present.

Poster Presentation

Presenters of the accepted posters are kindly asked to have them mounted before 03:00 pm on Friday, 15 February 2002. Poster presenters are expected to be present at their poster site during the Poster Session. Poster Board Size: 200 x 150 cm (width x height).

Technical Assistance

Speakers or poster presenters seeking for technical assistance with their presentations may contact the Registration Desk.

Social Events

During the congress participants and accompanying persons have a number of occasions to recover and to enjoy themselves in good company. Join others at the Welcome Cocktail, at the Wilhelm Tell Dinner or at the a tour.

Friday, February 15, 2002

Welcome Cocktail

Time:	06:00 pm to 08:00 pm
Location:	Casino Kursaal Interlaken

Saturday, February 16, 2002

Terrific *Wilhelm Tell" - Dinner

Time:	06:30 pm
Location:	Bus departure at the Casino Kursaal Interlaken
Cost:	Free of charge for full delegates and registered accompanying persons. CHF 150.00 for guests

Accompanying Persons' Tour Program

A special tour program was created for accompanying persons.

Friday, February 15, 2002

Visit of the Woodcarving in Brienz

An unforgettable trip to Brienz with is fascinating and world-famous woodcarving factories. We will visit the factory where all figures will be carefully handcarved by mastercarves. After the guided tour you will have the opportunity for a short shopping tour in Brienz.
(Guaranteed departure only with a minimum of 15 people)

Departure Time:	02:00 pm
Meeting point:	Casino Kursaal, Interlaken
Duration:	approx. 4 hrs
Price:	CHF 60.00 per person including superior coach, professional Guide E/D, woodcarving factory

Saturday, February 16, 2002

Visit of the Swiss capitol Berne

Let's discover the Swiss capitol Berne which is only a 45 minutes drive from Interlaken. You will see the sandstone buildings, historic towers and unique fountains just as a example of mediaeval civic architecture. Getting some information about the lively diversity of the city (Museum of fine Art, Toblerone chocolate foundation, bear pit the heraldic animal of the city, parliament house) and we will have some free time to discover the 6 km Arcades which have large selection of all kind of shops. In the afternoon we will return to Interlaken through the Emmental. (Guaranteed departure only with a minimum of 15 people)

Departure Time:	09.30 am
Meeting point:	Casino Kursaal, Interlaken
Duration:	approx. 7 hrs
Price:	CHF 80.00 per person including superior coach, professional Guide E/D, city tour in Berne (lunch is not included)

Sunday, February 17, 2002

Excursion to the Top of Europe
An unforgettable trip to the Bernese Oberland with its fascinating and world famous mountain peaks. From Lauterbrunnen you will enjoy a very special ride in a cog-wheel train up to Europe's highest railway station, the Jungfraujoch, at an altitude of 3454 m (11'333 ft). On the way up you will have a stop to visit the famous Ice Palace and the wall of Mount Eiger as well as the beautiful view of the panorama of the Alps. After spending some time at leisure we will take the train via Kleine Scheidegg to Grindelwald, a typical mountain village at the foot of Mount Eiger. After some free time in Grindelwald, we will return to Interlaken.
(Guaranteed departure only with a minimum of 15 people)

Departure Time:	09.30 am
Meeting point:	Casino Kursaal, Interlaken
Duration:	approx. 8 hrs
Price:	CHF 260.00 per person including superior coach, professional Guide E/D and the train ticket (lunch is not included)

General information In the mountains it is often very cold even through the sun shines and the Top of Europe is always covered with snow. We recommend warm clothes, sunglasses and a pair of solid shoes.

Sponsors

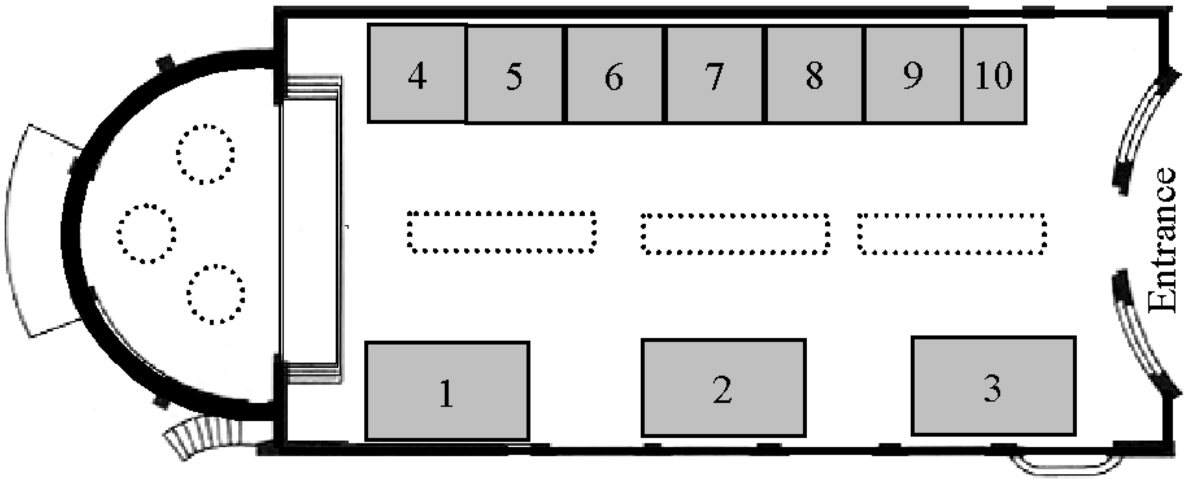
Founder's level

Assistance level

Asclepion Meditec
Nidek
Schwind eye-tech-solution
Topcon Corporation
Tracey Technology
Visx

Exhibition plan

The Exhibition is located in the "Ballsaal"



1. Alcon
2. Bausch and Lomb
3. Wavelight
4. Visx
5. Asclepion Meditec
6. Nidek
7. Schwind eye-tech-solution
8. Topcon
9. Tracey
10. Ryser-Optik

ABSTRACTS

COMPENDIUM OF ORAL PRESENTATION AND POSTER PRESENTATIONS

Edited by the local organizing committee of the
3rd International Congress of Wavefront Sensing and Aberration-Free Refractive Correction
February 15 – 17, 2002
Interlaken – Switzerland

Poster Presentations

Poster Session I: Wavefront Sensing Techniques

EXTENDED-SOURCE PYRAMIDIC WAVEFRONT SENSOR FOR THE EYE

(Ignacio Iglesias, Yves Julien, Pablo Artal)

Purpose: The most widely used technique to measure in real time the human eye's wavefront aberration is the Hartmann-Shack sensor (HSS). Although proved successful, a number of factors may limit the performance of the HSS for the eye; i.e., poor SNR, due to intraocular scattering and safe light levels, corneal reflections, etc. The search of viable alternatives to estimate the ocular aberrations other than the HSS is an interesting effort. In particular, we explored potential of a different kind of technique: the pyramid wavefront sensor, previously proposed in Astronomy by Ragazzoni (1996, J. Mod. Opt. 43,289).

Methods: We describe a modified version of the sensor utilizing an extended source and a glass pyramid to split the light in four beams. The intensity balancing between them gives direct information on the gradients of the aberration.

Results: Preliminary results of wave-front aberration measurements in the living eye obtained with this new sensor will be presented.

Conclusion: The method has potential advantages for ist use to measure the aberrations of the eye in real time: an adjustable gain and a continuous change of the sampling. These advantages can be of benefit for ocular aberration determination and for practical implementations of adaptive optics in the eye as well.

Contact: Ignacio Iglesias, Ph.D., Universidad de Murcia, Laboratorio de Optica, Campus de Espinardo (Ed.C), E-30071 Murcia, Spain;
phone: +34 968367220; fax: +34 968363528; E-Mail: iic@um.es

SHACK-HARTMANN SENSOR FOR DETECTION OF EXTREMELY CURVED WAVE FRONTS

(Johannes Pfund)

Purpose: In optical industry and medicine the fabrication and manipulation of aspherical optical surfaces have gained growing interest over the last years. One key point in this task is the ability to characterise the test sample reliably.
Normally an optical surface is characterised by reflecting a phase-conjugate wave front at the surface of the test sample. In this case the wave aberrations in the reflected wave front are directly proportional to the deviations of the sample from its ideal shape.
However, the beam shaping optics, e.g. a computer generated hologram, used for the generation of the aspherical test wave front can be very expensive in time and cost. Therefore, one could try to measure the topology of the surface by illuminating it with a more general wave front which is not exactly matching the surface. The critical points of such a constellation are on the one side the ability to measure the huge systematic wave aberrations and on the other side the calibration of the optical set-up.

Results: The Shack-Hartmann sensor system SHSLab uses a special algorithm for the expansion of the dynamic range of measurable wave front slopes. It allows to measure wave fronts with a local radius of curvature down to 10mm, i.e. 100 diopters. In order to prove this capability results are presented where this Shack-Hartmann sensor is applied in testing strongly curved wave fronts and in testing aspherical surfaces of different types.

Contact: Johannes Pfund, Dr. rer. nat., Fa. Optocraft GmbH, Reichswaldstr. 7,
D-91052 Erlangen Bavaria, Germany;
phone: +49 (9131) 8528396; fax: +49 (9131) 13508; E-Mail: pfund@optocraft.de

A PORTABLE WAVEFRONT SENSOR TO MEASURE OCULAR ABERRATIONS

(Jonathan Brooks, J C Dainty, A D Edwards, A R Fielder)

Purpose: A portable wavefront sensor intended for measuring the aberrations of the eye is currently under construction. The intended use of the sensor is to measure the aberrations of infants at the Neonatal Unit at the Queen Anne Hospital.

Methods: The wavefront sensor is based on the Shack-Hartman principle. The setup comprises a power supply, a laptop and the sensor, which can be handheld or supported and is contained within a volume of approximately 2500cm3. The fragility of the subjects imposes many design requirements. The levels of coherent light entering the eye will be very low (≤1μW). A targeting arm has been invoked due to the inability to ask the subject to fixate. The measurement procedure will be non-invasive and its duration will be short.

Results: The initial results will be presented at the meeting.

Conclusion: The long term goal of this work is to realise the possibility of performing clinical studies of the retina and retinal disease in-vivo.

Contact: Jonathan Brooks, MSci Physics, Photonics Group, Blackett Laboratory, Imperial College STM, London SW7 2BW, United Kingdom;
phone: +44 (0) 207 5947734; fax: +44 (0) 207 5947714; E-Mail: j.brooks@ic.ac.uk

IMPORTANT FACTS OF OCULAR WAVE FRONT MEASUREMENTS WITH SHACK-HARTMANN SENSOR BASED SYSTEMS

(Hartmut Vogelsang, Michael Bergt)

Purpose: To discuss frequently asked questions that are related to ocular wave front sensing with Shack-Hartmann based systems.

Methods: We make use of the Asclepion Wavefront Analyzer to demonstrate the influence of: the wave front propagation and the resulting distance dependence, a probe wave lengths far of the center of the visual sensitivity of the eye, the microoptic lenslet array on resolution and dynamic range, the higher order aberrations for the SCA treatment, and others.

Results: Shack-Hartmann sensor based systems combine superior resolution with a sufficient dynamic range. The use of infrared probe light is not limiting the ability to determine wave front distortions in the visible region but is advantageous in other aspects. The several aberration terms show different responses to deviations of the measurement and correction plane. To derive SCA values from Zernike coefficients one has to take into account higher order terms too.

Conclusion: To apply wave front sensing for diagnosis and refractive surgery one has to take into account device specific properties and the biophysics of the eye.

Contact: Hartmut Vogelsang, PhD, Asclepion-Meditec AG, Goeschwitzer Strasse 51-52, D-07745Jena, Germany;
phone: +49 (0) 3641 220 240; fax: +49 (0) 3641 220 262; E-Mail: hv@asclepion.com

EXACT COMPUTATION OF ZERNIKE AMPLITUDES OVER A REDUCED PUPIL DIAMETERS

(Daniel M. Topa)

Purpose: Ophthalmic measurements of the Zernike amplitudes are made at a variety of pupil sizes. Yet for purposes of comparing the amplitudes, it is necessary to use a common pupil size. This paper discusses how to a set of Zernike amplitudes and exactly comp. To demonstrate the similarity transform and affine transformations that connect a set of Zernike amplitudes a fixed pupil size to the amplitudes at a smaller pupil size.

Methods: This is a mathematical treatment and ideal data was used. An extensive validation over 500 CPU hours was perfromed.

Results: Out through a 20th order Zernike fit, the precision is a reasonable 10 decimals due to machine errors.

Conclusion: Sparse matrix arithmetic and integer tranformation matrices make the resampling process immediate and extremely

Contact: Daniel M. Topa, B.A. Physics, WaveFront Sciences, 14810 Central Ave SE, Albuquerque NM 87123-3905, USA;
phone: 505.275.4747; fax: 505.275.4749; E-Mail: dtopa@wavefrontsciences.com

COMPUTING WITH TAYLOR POLYNOMIALS IN LIEU OF ZERNKIKE POLYNOMIALS

(Daniel M. Topa)

Purpose: Efficient Computation of the Zernike Polynomials While the Zernike polynomial basis is an extremely valuable representation for ophthalmic measurements, it is an inefficient computational basis. For example, through 10th order, there are 505 element. To demonstrate a faster and more reliable method to compute Zernike amplitudes. To show that computer codes are far easier to write and that that they execute much faster.

Methods: This is a mathematical development. The theory is presentated along with an extensive validation.

Results: We have been successfully using the Taylor basis for over a year. The results agree with derivations done in the Zernike basis.

Conclusion: The Zernike amplitudes are much easier to compute in the Taylor representation. The transformation from the Taylor basis to the Zernike basis is exact and virtually instantaneous.

Contact: Daniel M. Topa, B.A. Physics, WaveFront Sciences, 14810 Central Ave SE, Albuquerque NM 87123-3905, USA;
phone: 505.275.4747; fax: 505.275.4749; E-Mail: dtopa@wavefrontsciences.com

THE NUMBER OF LENSLETS AND THE PRECISION OF THE ZERNIKE AMPLITUDES

(Daniel M. Topa, James K. Gruetzner)

Purpose: The precision of the Zernike amplitudes measured by an ophthalmic wavefront sensor is determined by several factors. Here we discuss how the sampling density or the number of lenlsets affects the precision of the computa. To explore how the sampling density (or number of lenslets) affects the precision of the Zernike amplitudes measured by various ophthalmic devices.

Methods: This is a theoretical study using perfect data. We present the results and the validation of the model.

Results: We quantify how the number of lenslets affects the standard deviations of the Zernike amplitudes.

Conclusion: Increasing the sampling density (using more lenslets) greatly improves the precision of the computation of the Zernike amplitudes.

Contact: Daniel M. Topa, B.A. Physics, WaveFront Sciences, 14810 Central Ave SE, Albuquerque NM 87123-3905, USA;
phone: 505.275.4747; fax: 505.275.4749; E-Mail: dtopa@wavefrontsciences.com

DEMONSTRATION OF SAMPLING FIELD SENSOR SURFACE MEASUREMENT

(Daniel Marks, Daniel L Marks, Remy Tumbar)

Purpose: We demonstrate that the Sampling Field Sensor (SFS), a novel wavefront sensor that combines the phase accuracy of interferometry with the vibration insensitivity of the Shack-Hartmann sensor (SHS), has the accuracy to measure extremely minute wavefront deviations. The SFS can replace the SHS as a more accurate and robust wavefront sensor in aberrometry measurements.

Methods: By constructing an interferometric microscope, we image the heights of patterned submicron structures on a copper plated silicon wafer. The heights of some structures correspond to fractions of a wavelength. The SFS produces the direct interference between samples, rather than the average wavefront tilt, providing a much simpler data inversion than the SHS.

Results: We present a relief map of submicron structures demonstrating the subwavelength height resolution of the SFS reconstruction. Based on two separate phase calibrations with a reference lens, we measure the RMS phase error to be less than 2 mrad per sample. Such subwavelength accuracy will translate to extremely high resolution local measurements of aberrations in ophthalamic sensing.

Conclusion: Unlike the widely used Shack-Hartmann sensor, the SFS method of shear enables a much higher accuracy phase measurement, and does so without compromising environmental insensitivity. This will enable a much more quantitative measurement of aberrations and a more localized, detailed assessment of refractive inhomogeneities.

Contact: Daniel Marks, PhD, PhaseOptics, LLC, 3525 W Peterson Ave Suite 320, , Chicago IL 60659, USA;
phone: +1-773-539-4275; fax: +1-773-539-5226; E-Mail: dmarks@phaseoptics.com

A RECONSTRUCTOR FOR OPHTHALMIC WAVEFRONT SENSING

(Daniel M. Topa)

Purpose: This paper describes a wavefront reconstructor optimized for the new generation of ophthalmic wavefront sensors. Wavefront reconstruction is the step which converts the the Shack-Hartmann lenslet output into refactive terms like Zernike polynomial. To describe the mathematical development and simulation results from using a wavefront reconstructor developed for the Shack-Hartmann wavefront sensor.

Methods: This is is a mathematical development and the details are shown explicitly along with extensive validation and comparison to existing reconstructors.

Results: Ideal data is analyzed using the new reconstructor as well as the existing reconstrutor developed by W. Southwell. In general the new reconstructor offers an improvement in resolution and precision and is consistently superior at resolving the smallest details.

Conclusion: The new reconstructor is in general more precise than existing reconstructors and always yields superior resolution of the smallest features.

Contact: Daniel M. Topa, B.A. Physics, WaveFrotn Sciences, Inc., 14810 Central Ave SE, Albuquerque NM 87123-3905, USA;
phone: 505.275.4747; fax: 505.275.4749; E-Mail: dtopa@wavefrontsciences.com

Poster Session II: Clinical Wavefront Sensing

EFFECTS OF RACE AND REFRACTIVE ERROR ON CORNEAL ABERRATIONS AND WHOLE-EYE ABERRATIONS IN SINGAPOREAN SCHOOL CHILDREN.

(Andrew Carkeet, Hai Dong Luo, Seang Mei Saw, Tat Keong Chan, Donald TH Tan.)

Purpose: To assess whether refractive error and race are associated with differences in corneal monochromatic aberrations and in whole-eye monochromatic aberrations in Singaporean School children.

Methods: Using a Tomey TMS 2 topographer and CTView 2.05 software we measured corneal aberrations of 311 children (mean age 9.0 years) as part of the Singapore Cohort Study of the Risk Factors for Myopia. On 273 cyclopleged children we also measured whole-eye aberrations using a Bausch and Lomb Zywave aberrometer. In both cases wavefront aberrations were expressed as the first 21 Zernike coefficients for a 5 mm diameter pupil.

Results: Aberrations (whole-eye and corneal) are correlated between right and left eyes of individual subjects with, in general, the correlation coefficients decreasing as Zernike order increases. Corneal aberrations were also correlated with whole-eye aberrations, with strongest correlations for lower order aberrations and weaker correlations for higher order terms. 2) MANOVA showed that there were no significant refractive error group effects on corneal aberration levels and only slight refractive error effects on whole-eye aberrations. 3) Malay subjects had significantly different amounts of higher order corneal aberrations from Chinese subjects, and similar differences also occurre

Conclusion: Higher order aberrations (either corneal or whole eye)are relatively independent of refractive error status in Singaporean Children. The difference in whole-eye aberrations between Malay subjects and Chinese subjects is similar to the inter-race difference in corneal aberrations and is therefore predominantly a consequence of differences in corneal shape.

Contact: Andrew Carkeet, B.App.Sc. (Optom) (Hons), Ph.D., Singapore Eye Research Institute, Singapore National Eye Centre, 11 Third Hospital Ave, Singapore 168751, Republic of Singapore;
phone: 65+ 3224565; fax: 65+ 3224599; E-Mail: seri_acarkeet@snec.com.sg

ACCURACY, REPEATABILITY AND INSTRUMENT MYOPIA WITH THE COAS SHACK-HARTMANN ABERROMETER

(Thomas Salmon, Roger W. West, PhD, OD, Wayne Gassser, Todd Kenmore)

Purpose: We compared accuracy, repeatability and instrument myopia of an ophthalmic Shack-Hartmann aberrometer, the Complete Ophthalmic Analysis System (COAS; Wavefront Sciences, Inc.) with subjective refraction and autorefraction.

Methods: Sphere and cylinder of 20 healthy myopic eyes (0 to -12 D sphere; 0 to -2 D cylinder) were measured by autorefraction (NIDEK ARK 2000), subjective phoropter refraction and the COAS, with and without cycloplegia (1% cycloplentolate). We assumed that subjective refraction provided the best estimate of refractive error, so accuracy for the COAS and autorefractor was defined as their mean differences from subjective refraction. Differences and means were computed using power vectors. Repeatability was assessed following the difference versus mean analysis described by Zadnik, et al (IOVS, 1992). We estimated instrument myopia by computing the difference in refractive error for the same eye measured with and without cycloplegia.

Results: Mean differences between COAS and subjective refractions (left eyes, n=20) were -0.02 -0.30 x 0 without cycloplegia and -0.10 -0.17 x 8 with cycloplegia. These were not significantly different from zero error (Hoteling's T2 statistic; $p<0.01$). Autorefractor accuracy was essentially the same. Repeatability for vertical meridian power, expressed as 95% limits of agreement, was ±0.30 D, which is similar to published reports of repeatability for autorefraction. COAS instrument myopia was +0.02 D (slight hyperopia); the autorefractor showed -0.21 D.

Conclusion: Accuracy, repeatability and instrument myopia with the COAS is at least as good as clinical autorefraction and agrees well with subjective refraction. In addition, the COAS can measure higher order aberrations.

Contact: Thomas Salmon, OD, PhD, Northeastern State University, 1001 N. Grand Avenue, Tahlequah, Oklahoma 74464, USA;
phone: (918) 456-5511 ext. 4011; fax: (918) 458-2104; E-Mail: salmon@ipa.net

RELIABILITY AND ACCURACY OF THE VISX WAVESCAN ABERROMETER IN HIGHER AND LOWER ORDER ABERRATIONS

(Douglas Koch)

Purpose: To evaluate the accuracy and reproducibility of aberrations measured with VISX WaveScan technology.

Methods: A series of eyes were measured, including normal, pre-operative patients, as well as post-op LASIK, PRK, Intacs and LRI patients. Among these, another series underwent three consecutive wavefront measurements. Subjective manifest refraction and wavefront measurements were taken for all eyes.

Results: In assessing mean accuracy of lower order aberrations, WaveScan measurements for spherical equivalent were within –0.26D of manifest refraction measurements. In assessing repeatability, the mean standard deviation of three consecutive measurements for spherical equivalent was 0.13D. Data will also be presented on the repeatability of higher order aberrations in consecutive measurements, based on individual Zernike terms.

Conclusion: This study indicates that, for most eyes, WaveScan technology offers excellent accuracy and reliability.

Contact: Douglas Koch, MD, Baylor College of Medicine, 6501 Fannin, NC 200, Dept. of Ophthalmology, Houston TX 77030, USA;
phone: (713) 798-6443; fax: (713) 798-3027; E-Mail: dkoch@bcm.tmc.edu

EVALUATION OF A SCANNING-SLIT ABERROMETER (NIDEK OPD SCAN) AND A SHACK-HARTMANN ABERROMETER (WAVEFRONT SCIENCES COAS WAVEFRONT ANALYZER)

(Daniel Durrie, Ethan E Huisman, Paul M Petelin, Jr)

Purpose: To assess the accuracy and repeatability of the output of a scanning-slit aberrometer, the Nidek OPD Scan, and a Shack-Hartmann aberrometer, the Wavefront Sciences COAS Wavefront Analyzer in measuring wavefront aberrometry and refractive errors in virgin eyes and eyes having undergone previous refractive surgery.

Methods: A prospective study using the Nidek OPD Scan and Wavefront Sciences COAS Wavefront Analyzer to measure higher-order wavefront aberrations and refractive errors in a series of virgin and post-surgical eyes. Statistical analysis will be performed between the two devices for measurements of 3rd and 4th order Zernike coefficients and the total root-mean-squared (RMS) of the higher-order aberrations. Additionally, the spherical equivalent, sphere, and cylinder values obtained with the Nidek OPD Scan and Wavefront Sciences COAS Wavefront Analyzer will be statistically compared to values measured by manifest refraction.

Results: The results of this study are currently being compiled. Upon completion of the series of virgin and post-surgical eyes, the higher-order Zernike coefficients for each device will be statistically analyzed to determine if they are comparable and reproducible. The refractive error as measured by each device will be compared to the manifest refraction.

Conclusion: Results will be statistically analyzed to determine if they are comparable and reproducible with regards to the wavefront aberrometry and measured refractive error of each device.

Contact: Daniel Durrie, MD, Hunkeler Eye Centers, 5520 College Blvd Ste 200, Overland Park, KS 66211, USA;
phone: 913-491-3737; fax: 913-491-9650; E-Mail: ddurrie@novamed.com

CORNEAL ABERRATIONS - MEASUREMENT REPEATABILITY

(Marine Gobbe, Michel Guillon, CecileMaissa)

Purpose: Contact lens or refractive surgical customised corrections that aim to improve visual performance beyond the results achieved by solely correcting sphere and cylinder require the reliable determination of specific higher order terms and overall higher order corneal and ocular aberrations for individual eyes. The aim of the current investigation was to determine the repeatability of corneal aberrations measurement.

Methods: Ten subjects were measured on 10 different days using the Keratron videokeratoscope. The height data files were analysed using CTView to obtain the Zernike coefficients and the higher order wavefront error (WFE) up to the 10th order. The within and between visits repeatabilities were calculated for apertures of 3, 4.5 and 6mm at the 95% confidence level.

Results: The overall WFE absolute repeatability was similar for the 4th and 10th order analysis and poorer for larger apertures (Repeatability 3mm = 0.004um; 4.5mm = 0.019um; 6mm = 0.103um). The absolute repeatability for individual Zernike coefficients was coefficient dependent; the poorest repeatability was recorded for coma like aberrations (Repeatability 3mm = 0.06um; 4.5mm = 0.125um; 6mm = 0.190um). The relative repeatability compared to the population means was good for WFE (5 to 20%) but poor for some individual Zernike coefficients.

Conclusion: Videokeratoscope clinical repeatability is sufficient to reliably determine WFE at a single session, but may require several visits to determine reliably some Zernike coef

Contact: Marine Gobbe, MSc, Optometric Technology Group, 42 Vauxhall Bridge Road, London SW1V 2RX, UNITED KINDOM;
phone: (00 44) 207 630 9124; fax: (00 44) 207 630 8927; E-Mail: mguillon@otg.co.uk

COMPARISON OF PRE- AND POST-LASIK HIGH ORDER ABERRATIONS MEASURED AT VARIOUS OPTIC ZONES

(Rossen Hazarbassanov, Igor Kaiserman and Aharon Grimbaum)

Purpose: To quantify the effect of the abberometer's optic zone on the evaluation of the high order aberrations pre- and post-LASIK.

Methods: 102 eyes of 51 myopic-astigmatic patients (-1.5D to -13.25D) that underwent LASIK (WaveLight-Allegretto scanning-spot laser) were examined using the WaveLight WaveFront analyzer (a Tscherning aberrometer) pre-operatively and 1 day, 1week and 1 month post-op. The aberrometry was performed at various optic zones (OZ) ranging from 4 to 6.5 mm (under mydriasis). In addition subjective and objective refraction, corneal topography (Oculus) and pupilometry were performed. We looked at the Zernike decomposition of the wave aberration up to the 6th order and compared the RMS of the wavefront error for the high order aberrations (3-6th order) including coma and spherical aberrations.

Results: Post-LASIK the high order aberrations in general and coma and spherical aberrations specifically increased significantly (from a mean of 0.22ìm to 0.49ìm). The difference in the RMS of high order aberrations was significantly larger when measured through a 6.5mm OZ compared to a 4mm OZ. The low order aberrations such as defocus and astigmatism were much less affected by the size of the aberrometer's OZ.

Conclusion: While correcting defocus and astigmatism, LASIK induces a significant increase in high order aberrations especially at optic zones beyond 5mm.

Contact: Rossen Hazarbassanov, MD, American Lasers Medical Center, UMI Building, New industrial zone, Rishon LeZion 49435, Israel;
phone: +97253229533; fax: +972-26416302; E-Mail: hrossen@hotmail.com

SPHERICAL ABERRATION IN NORMAL, DILATED, IOL AND LASIK PATIENTS

(Raana Anwaruddin, Jochen Straub, Jim Schwiegerling)

Purpose: Wavefront sensing permits measurement of higher order aberrations. We performed repeated measures of Shack-Hartmann aberrometry to determine the repeatability, and to characterize fourth and sixth order spherical aberration in Normal Subjects (NL, n=17), dilated Normal Subjects(DN, n=7), pseudophakic subjects (IOL,n=2), and post LASIK patients (LASIK, n=7), where each subject had a minimum of three measures with a pupil size at least 6 mm.

Methods: Zernike expansion was performed for the maximum observed pupil size, and then rescaled for 6 mm. Confidence interval estimation on z(4,0) and z(6,0) was then determined within each subject. The mean value of z(4,0) and z(6,0), as well as it being significantly different from zero ($p<0.05$) was determined using the Stata statistical package.

Results: Mean and Standard deviation of 4th order spherical aberration was found as follows: Normal (mean=0.06 microns +/- 0.14 microns), Dilated Normal (0.09 microns +/- 0.10 microns), IOL (0.58 microns +/- 0.25 microns) and LASIK (0.45 microns +/- 0.12 microns) . Sixth order aberration was correlated with fourth order for all groups other than normals.

Conclusion: Pupillary dilation appears to change higher order aberration content of the eye. Both IOL and LASIK subjects have signifantly ($p<0.05$) higher 4th order spherical aberration than normal patients. No statistically significant differences were found between the Normal and Dilated Normal Groups.

Support: JM NEI/NIH ey11155 and ey13152, JS the Whitaker Foundation

Contact: Joseph Miller, MD, MPH, University of Arizona, 655 N Alvernon Way, Ste 108, Dept. of Ophthalmology, Tucson Arizona 85711, USA;
phone: 520-322-3800; fax: 520-321-3665; E-Mail: jmiller@eyes.arizona.edu

CONSISTENCY OF HIGHER ORDER ABERRATIONS WITH THE WAVELIGHT TSCHERNING ABERROMETER

(Arthur Cummings)

Purpose: To ascertain how consistent higher order aberrations are in the same eye while changing the lower order aberrations

Methods: Wavefront measurements were made on ametropic eyes. These eyes were then corrected with corrective lenses and the wavefront maps were studied

Results: Higher order aberrations remained very consistent while total aberrations varied with the different corrective lenses

Conclusion: Wavefront measurements of higher order aberrations appears accurate and consistent with the Wavelight Tscherning Aberrometer

Contact: Arthur Cummings, FRCSEd, Wellington Ophthalmic Laser Clinic, 2A Wellington Road, Ballsbridge, Dublin Co. Dublin D4, Ireland;
phone: +353-1-6608821; fax: +353-1-6602816; E-Mail: abc@woclinic.iol.ie

TEMPORAL DYNAMICS OF VISION: ANALYSIS OF ABERRATIONS USING A SHACK-HARTMANN ABERROMETER

(Daniel R. Neal, James Copland, Larry Voss)

Purpose: A Shack-Hartmann wavefront sensor is an ideal tool to study the temporal dynamics of vision. A measurement rate of 30 Hz allows the clinician to study temporal variations over time scales ranging from hundreths of a second. To study the temporal dynamics of human vision, including the effect of accomadation on higher order aberrations at various time scales. This is important since all current refraction schemes are purely static, yet the eye is contantly responding to external stimulus.

Methods: We use a Shack-Hartmann aberrometer (the Complete Ophthalmic Analysis System [COAS] by WaveFront Sciences, Inc.) to measure the temporal variations of human vision for a number of subjects. The aberrometer reports both low order aberrations (focus and astigmatism) as well as a number of higher order aberrations. The change in these aberrations over time was studied under different conditions. A wide variety of time scales was studied.

Results: The lower order terms were naturally dominated by accomodation. However, coupling between the spherical aberration and defocus terms was observed. Furthermore, some rapid dynamic effects were observed that appear to
be linked to the heart rate.

Conclusion: An accurate assessment of the temporal dynamics associated with human vision may be important in understanding both accomodation and in selecting appropriate refraction. Analysis of temporal variations is especially important for refractive surgery where a permanent, fixed change is applied to the visual system.

Contact: Daniel R. Neal, PhD Aeronautical Engineering, WaveFront Sciences, 14810 Central Ave SE, Albuquerque NM 87123-3905, USA;
phone: 505.275.4747; fax: 505.275.4749; E-Mail: dtopa@wavefrontsciences.com

DOES INCREASED NEGATIVE SPHERICAL ABERRATION OR A SLIGHTLY MYOPIC RESIDUAL CORRECTION EXPLAIN MULTIFOCALITY AFTER HYPEROPIC LASIK

(Tomy Starck, Leana S. Long M.D., R. A. Applegate, OD, PhD.)

Purpose: To investigate whether LASIK induced negative spherical aberration or a small residual myopic correction can explain multifocality following hyperopic LASIK.

Methods: Study and control patients were at least 49 years of age. Eligible study eyes had distance and near visual acuities of 20/30- or better following hyperopic LASIK, and a residual manifest refraction of 0.50 D or less. Controls eyes met the same criteria and had a near visual acuity of 20/70 or worse postoperatively. Data collected included: whole eye wavefront aberrations, refractive error, and corneal topography

Results: Six eyes in four patients were identified as study eyes and paired with an equal number of control eyes. Both groups showed LASIK induced negative spherical aberration ( ). However, there was no statistically significant difference in between study and control eyes for either corneal first surface wavefront aberration (calculated from corneal topography using CTView) or in whole eye wavefront (measured with a Shack/Hartmann aberrometer)($p = 0.16$). Likewise, there was no significant difference found in residual refractive errors. There was a trend in the study eyes to have higher preoperative hyperopic errors.

Conclusion: The multifocality effect occasionally seen in post-hyperopic LASIK eyes does NOT appear to be due to increased negative spherical aberration or myopic residual refractive error. Given the small sample size may mask important differences, we remain cautious in this interpretation.

Contact: Tomy Starck, M.D., Cornea & Refractive Surgery Services, Univ. of Texas Health Science Center San Antonio, Dept. of Ophthalmology, San Antonio Texas 78284-6230, USA; E-Mail: starck@uthscsa.edu

Poster Session III: Wavefront corrections

A MODEL FOR TESTING THE CORRECTION OF OPTICAL ABERRATIONS

(Werner Förster, M.E.Zirm, MD, H.B.Dick, MD)

Purpose: To present a model to create and correct higher optical aberrations.

Methods: In a practical aberration-free eye model a PMMA plate is inserted. The TOSCA software (Asclepion Meditec, Germany) is used to create optical higher aberrations on the PMMA plate which are dominated by one Zernicke polynom with the MEL 70 Excimer-laser (Asclepion Meditec). The higher optical aberrations are analyzed using a high resolution Shack-Hartman sensor (WASCA by Asclepion Meditec). Then a second wavefront guided Excimer-laser ablation is performed to correct the formerly created higher aberations.

Results: Using the TOSCA software (Asclepion Meditec) optical aberrations dominated by one polynom can be created. In most cases the created aberrations can be corrected or reduced using the WASCA system and the MEL 70.

Conclusion: We present a model to test the efficiancy of wavefront guided Excimer-laser ablations.

Contact: Werner Förster, MD, University Eye Hospital Münster, Eye Centers Zirm, Meinhardstrasse 5, A-6020 Innsbruck, Austria;
phone: +43-512-7273; fax: +43-512-7273-1; E-Mail: office@zirm.net

ADAPTIVE OPTICS SCANNING LASER OPHTHALMOSCOPE

(Austin Roorda, Fernando Romero-Borja, William J. Donnelly, Tom J. Hebert, Hope Queener)

Purpose: Scanning laser ophthalmoscopes (SLO) provide axial sectioning capability, enhanced contrast and the potential for improved lateral resolution over conventional ophthalmoscopes. These advantages, however, are limited by blur due to aberrations in the eye's optics. We demonstrate a method to implement adaptive optics into an SLO as a means to reduce these aberrations, thus realizing the full benefits of SLO imaging.

Methods: A custom-built Adaptive Optics SLO (AOSLO) has been developed at the University of Houston. The AOSLO takes 512 X 512 images at 30 frames per second. The AO system employs a Shack-Hartmann wavefront sensor coupled to a Xinetics 37-channel deformable mirror. Correction and imaging in the eye is done through a 7-mm pupil. Other features of the AOSLO include a continuously variable field size ranging from 3 to 1 degree, a common light source and common optics for wavefront sensing and imaging, AO assisted axial sectioning, the ability to image at multiple wavelengths, and all-digital image acquisition and storage.

Results: Experiments have been done on both artificial and human eyes. Imaging experiments on the artificial eye were used to quantify the improvements in resolution and compare them with theoretical expectations. Early retinal imaging results with the AOSLO show improved contrast, resolution and light throughput.

Conclusion: Adaptive optics can be used effectively to improve image quality in a scanning laser ophthalmoscope. These instruments may find useful applications in both basic and clinical science.

Contact: Austin Roorda, PhD, University of Houston, 505 J. Davis Armistead Building, Houston Texas 77204-2020, USA;
phone: 713-743-1952; fax: 713-743-2053; E-Mail: aroorda@uh.edu

ADAPTIVE OPTICS: REAL-TIME COMPENSATION OF VISUAL ABERRATIONS WITH THE VISX WAVESCAN 2

(Frieder Loesel)

Purpose: To understand the benefits of compensating for visual aberrations with adaptive optics technology using with the VISX WaveScan 2 diagnostic instrument.

Methods: Using hundreds of data points, the WaveScan 2 offers objective, refractive measurement of the eye. This creates an individual map of all refractive errors. The WaveScan 2 recognizes all refractive errors in the eye and compensates for aberrations with an active mirror. More than 40,000 movable micro-mirror facets correct wavefront deformations and create an optimum visual image for the patient.

Results: Case studies will be presented with realized visual improvements in various patients, related to their wavefront error.

Conclusion: The WaveScan 2 provides data for personalized treatment and patient preview of surgical results.

Contact: Frieder Loesel, PhD, 20/10 Perfect Vision, Waldhofer Str. 100,
D-69123 Heidelberg, Germany;
phone: +49-6221-75933-10; fax: +49-6221-75933-21; E-Mail: loesel@2010pv.com

Poster Session IV: Others

30 REASONS WHY WE CANNOT ACHIEVE SUPER VISION USING ONLY EXCIMER LASER.

(Isaac Lipshitz, Dotan Gad, M.D.))

Purpose: Achieving super vision on a consistant basis by using. Excimer laser technology is the goal of the laser industry as well as surgeons.
Can this be achieved? We will try to explain why not.

Methods: There are 4 main reasons for not being able to achieve this goal.
1. Inherent physiological differences between various eyes.
2. Uncontrolable changes optical changes during the healing process.
3. Technological limitations of surgical equipment.
4. Uncontrolable surgeon dependent variables.

Results: We identified 30 reasons of these main 4 groups that show why we cannot achieve consistant super vision by only using Excimer laser technology.

Conclusion: Consistant super vision cannot be achieved using. Excimer technology alone.

Contact: Isaac Lipshitz, MD, Ophthalmic Health Center, 40 Einstein St., Tel Aviv 69101, Israel;
phone: 972 3 6437925; fax: 972 3 6437926; E-Mail: lipshitz@netvision.net.il

EQUATION FOR CORNEAL ASPHERICITY AFTER REFRACTIVE SURGERY

(Jose Ramon Jimenez)

Purpose: To determine the exact theoretical asphericity after refractive surgery when the parabolic approximation of the Munnerlyn formula is performed.

Methods: From a least-square analysis and considering the conicoid model for the anterior cornea, we calculate the final asphericity (p'-factor) from pre-surgery asphericity and the radii pre- and post-surgery.

Results: Final p'-factor is given by $p'=p(R'/R)^3$ with R' being the final radius of curvature, with R and p being the pre-surgical radius and p-factor, respectively. This equation for post-surgical asphericity may be useful in studying the influence on asphericity of different surgical variables allowing comparisons of real asphericity with the asphericity that should theoretically result. The equation for p'-factor agrees with experimental data on asphericity and explains the increased spherical aberration after refractive surgery as well as the deterioration of retinal-image quality that some researchers have found experimentally. It also explains experimental results that show the high asphericity values after refractive surgery reported by some authors, values abnormally high with respect to the averages in the normal or myopic population. The equation also accounts for the fact that for myopes the cornea changes from prolate to oblate in shape and provides the reason why this trend is more accentuated with the degree of myopia, given that as the myopia increases so does R'/R and, therefore, p'.

Conclusion: These values for post-surgical asphericity justify the proposals by different authors for finding new algorithms for the ablation depth that minimize the eye aberrations in order to optimize the observer's visual performance.

Contact: Jose Ramon Jimenez, PhD, University of Granada, Departamento de Óptica. Facultad de Ciencias. Univ, Granada 18071, Spain;
phone: 34-958246165; fax: 34-958248533; E-Mail: jrjimene@ugr.es

FLYING SPOT VERSUS FRACTAL MOVED MASK SYSTEM: INVESTIGATION OF THE KERATOCYTE VITALITY AFTER EXCIMER LASER ABLATION (193 NM)

(Hans-Henner Becker, Matthias Walke)

Purpose: The aim of this study was to investigate excimer laser induced cell damage in vital cornea by two laser devices. We performed photoablation with CHIRON TECHNOLAS CERACOR 217 (single flying spot system) and COHERENT SCHWIND CERATOM (fractal moved mask system), using PTK- and PRK-mode, respectively, and different frequencies.

Methods: Porcine eyes were freshly enucleated, followed by excimer laser ablation (n = 72).
- PTK-mode (100 shots, ablation zone = 6,0 mm) was performed with 3 different frequencies (2, 5, 50 Hz) by both laser devices (6 groups, each group n = 6).
- PRK-mode (myopia: - 4,0 diopter, ablation zone = 6,0 mm) was achieved with 3 different frequencies (2, 5, 50 Hz) by the same two laser devices (6 groups, each group n = 6).
- After sterile corneoscleral trephanation, we performed Live/ Dead Kit® fluorescence staining (vital cells = green/ dead cells = red fluorescence, Molecular Probes Inc., USA); for detailed visualisation of the fluorescent keratocytes a confocal laser scanning microscope (ZEISS, Jena, Germany) was used.

Results: Avital keratocytes were only detected
- at the edge of or within the spherical ablation area (n = 72)

The anteroposterior depths of the avital keratocytes were found to be
- 1-2 cell layers within the spherical ablation area (n = 72)
- 2-4 cell layers at the edge of the photoablation zone (n = 72)

Conclusion: The depth of the stromal damage was independent of the excimer laser device, the ablation mode (PTK versus PRK) and the used frequency (2, 5, 50 Hz) in all corneae.

Contact: Hans-Henner Becker, Assistenzarzt, UniversityEyeHospital, Doberanerstr.140, D-18057 Rostock, Germany; phone: 0381-2004568;
fax: 0381-4948587; E-Mail: hans-henner.becker@med.uni-rostock.de

FLAP CREATION WITH A ULTRASHORT PULSE INTRASTROMAL LASER MICROKERATOME

(Frieder Loesel)

Purpose: To evaluate the precision and dissection quality of corneal flaps generated with a ultrashort pulse laser microkeratome.

Methods: Ultrashort femtosecond laser pulses in the near infrared wavelength range were focused into the corneal stroma of porcine eyes in vitro. The pulse energy was chosen above the threshold for plasma-mediated ablation. The laser's focus was scanned inside the cornea in a three-dimensional pattern to generate a hinged flap cut. After the procedure the flap was lifted and the quality of the stromal bed was evaluated.

Results: The flap cuts with the ultrashort pulse laser microkeratome were of high dissection quality and showed good reproducibility of the flap thickness.

Conclusion: Use of the ultrashort pulse intrastromal laser for generating LASIK flaps appears to have several advantages over mechanical microkertomes. The ultrashort pulse laser has high potential for making flap cuts safer and more predictable.

Contact: Frieder Loesel, PhD, 20/10 Perfect Vision, Waldhofer Str. 100, D-69123, Heidelberg N/A, Germany;
phone: 49-6221-75933-10; fax: 49-6221-75933-21; E-Mail: Loesel@2010pv.com

MEASURING CORNEAL PACHYMETRY WITH A ROTARY SCANNING SYSTEM

(Sandra Franco, José B Almeida, Manuel Parafita)

Purpose: Last year we present a technique that allows the measurement of the corneal thickness along a vertical meridian from optical sections obtained using a biomicroscope.
The aim of this paper is to present a new system that allows a rotary scanning of the cornea and consequent measurement of the corneal thickness along any meridian.

Methods: The cornea is illuminated with a light beam which is previously expanded in a fan by a small cylindrical lens whose plane is rotated to explore the whole cornea. The light diffused by both corneal surfaces is collected by two video cameras placed at an angle with the light beam.

Results: The corneal thickness along two perpendicular meridians was measured in 4 right eyes from optical sections obtained with the new system. The algorithm to compute the thickness from optical sections was the same already presented by the authors.

Conclusion: With this system we expect to be able to measure the topography and thickness of whole cornea. The rotary scanning of the cornea simplifies the mechanics and eliminates some image processing problems present in translation scanning devices.

Contact: Sandra Franco, Physics, Physics Department- Universidade do Minho, Campus de Gualtar, Braga 4710-057, Portugal;
phone: +351253604333; fax: +351253678981; E-Mail: sfranco@fisica.uminho.pt

FINDING THE CENTER OF THE PUPIL AND THE FIDELITY OF THE ZERNIKE AMPLITUDES

(Daniel M. Topa)

Purpose: Aligning the center of pupil with the center of the unit disk that maps the Zernike polynomials is very important. When the pupil center is aligned with the origin of the unit disk the problem of finding the Zernike amplitudes is a simple linear least. To study how pupil centration ambiguities affect the fidelity Zernike amplitudes in ophthalmic measurements.

Methods: This is a theoretical development done by studying ideal data and making exact computations.

Results: We present results showing two things. First, we quantify the effect of the centration ambiguity on the precision of the Zernike amplitudes. Second we show that it may be possible to defeat the centration ambiquity and find the true pupil center in limited cases.

Conclusion: The centration of the unit disk is very important to a precise determination of the Zernike amplitudes. In an ideal system, one is at times able to find the true pupil center by watching variations in chi squared merit function.

Contact: Daniel M. Topa, B.A. Physics, WaveFront Sciences, 14810 Central Ave SE, Albuquerque NM 87123-3905, USA;
phone: 505.275.4747; fax: 505.275.4749; E-Mail: dtopa@wavefrontsciences.com

EXPERIMENTAL RESULTS ON PREPARING LASER-SHAPED STROMAL IMPLANTS FOR LASER-ASSISTED INTRASTROMAL KERATOPHAKIA (LAIK) IN EXTREME COMPLICATED LASIK CASES

(Mirko Jankov, Michael C Mrochen, Theo Seiler)

Purpose: Experimental evaluation on the feasibility of preparing laser shaped stromal implants from a donor eye for possibly correcting some extreme cases of high hyperopia with irregular astigmatism and exceptionally thin corneal bed.

Methods: Fresh enucleated porcine eyes were used to perform LAIK under experimental conditions. The entire bulbus was positioned onto the eye holder and filled with BSS through the optical nerve to restore the normal IOP. The procedure was initiated with mechanical de-epithelisation using a hockey knife. Lamellar microkeratotomy was performed using a commercially available microkeratome with a flat thickness of 130 microns and a flap diameter of approx. 9.5 mm. The cornea of the porcine eye was then photoablated with a regular Sph: +8.00 D (OZ: 7.0 mm) PRK treatment by a scanning-spot excimer laser Allegretto (Wavelight Laser Technologie AG, Erlangen, Germany). A customized scanning software algorithm was used to create a circumferential cut with internal diameter of 6.5 mm. The lenticule was then removed from the stromal bed and measured by a surface profiling system.

Results: Under the surgical microscope the lenticules seemed perfectly round, with regular surface and relatively transparent. The averaged surface profile of 25 porcine corneas demonstrated a good parabolic shape with well-predicted edges. Individual variation of the lenticules, not seen in previous PMMA ablations, were as large as 20 microns and are probably due to a long death-to-preparation time of the porcine corneas (> 4 hours), as well as because of corneal size and curvature differences between the porcine and the human eye for which the microkeratome is designed.
Conclusion: The use of modern scanning-spot excimer lasers and microkeratomes enables us to produce stromal lenticules that might be implanted into the eye for correction of high hyperopia, irregular astigmatism or to manage complicated LASIK patients with a thin residual stromal bed.

Contact: Mirko Jankov, MD, Augenklinik, University of Zurich, Frauenklinikstr 24, , CH-8091 Zurich, Switzerland;
phone: ++411 255 4983; fax: ++411 255 4900; E-Mail: mjankov@yep.com.br

INITIAL EXPERIENCE IN ADJUSTING THE LADARVISION EXCIMER LASER NOMOGRAM

(Mauro Campos, Frederico Pena, Marta Sartori, Erica Canarim)

Purpose: To evaluate and compare the refractive results of LASIK and PRK for myopia and myopic astigmatism achieved during one month prior to and one month after surgical technique and nomogram adjustments applied to the LadarVision Excimer Laser

Methods: LASIK or PRK was performed on 87 eyes (Mean E.E. –4.2 ± 2.1 D) before (group I) and 88 eyes(Mean E.E. –3.6 ± 2.0 D) after (group II) surgical technique changes and LadarVision nomogram adjustments. To evaluate the the impact of such modifications, the following main outcomes measures were retrospectively analyzed: Uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), one-month postoperative residual spherical equivalent (PRSE), postoperative complication rate, and loss of postoperative BCVA.

Results: UCVA was ³ 20/25 at last visit for 52.4% of the group I-eyes, compared to 77% of the group II-eyes ($p < 0.05$). Out of the patients with UCVA £ 20/25, residual spherical equivalent was within ± 0.50 D range for 73.2% in group I, as opposed to 91.9% of the group II cases examined one month post operatively. Loss of two or more lines of BCVA occurred on 2.6% of group I and 2.3% of group II

Conclusion: Surgical technique and nomogram adjustments did improve predictability and safety of Ladar Vision – operated eyes

Contact: Mauro Campos, MD, Paulista School of Medicine, Apto 71 Al Joaquim e Lima 984 JD Paulistano, Sao Paulo 01403-000, Brazil;
phone: 5511 32844419; fax: 5511 32891522; E-Mail: MCAMPOS@POBOX.COM

WAVELET ANALYSIS FOR DETECTION OF CORNEAL IRREGULARITIES AFTER PRK

(Achim Langenbucher)

Purpose: To demonstrate a mathematical method for multiscalar decomposition of discrete corneal topography height data into a space-scale space using wavelet analysis techniques, and to demonstrate the clinical applicability of these computations in the post-PRK cornea.

Methods: Ten patients after PRK with myopia (group I, n=7, -2.0 to -7.5 diopters) and myopic astigmatism (group II, n=3, equivalent -2.25 to -6.5 diopters) were seen preoperatively and 3 and 12 months after PRK with the Asclepion MEL 60 excimer laser. Patients were assessed using corneal topography analysis (TMS-1), subjective refraction, and best-corrected visual acuity (VA) at each interval. Two-dimensional biorthogonal wavelets with the order 6.8 at the scales j=1-4 revealed the following parameters: root-mean square (RMSDEV) and mean absolute (MEANDEV) deviation and maximum absolute height of the peaks or pitches (MAXPEAK) relative to the reference surface specified with the approximation component of scale j=4. RMSDEV was correlated with the VA at various follow-up intervals. The multiscalar basis components: roughness, waviness and form were separated and recovered from the wavelet soft thresholding techniques. Peaks and pits within the three-dimensional corneal surface topography were detected and localized using the wavelet hard thresholding techniques.

Results: In group I the RMSDEV and the MEANDEV increased from 1.31?0.89 / 1.56?0.79 ?m preoperatively to the 3 months follow-up (3.14?1.41 / 3.92?1.88 ?m) and thereafter decreased continuously to the end of the follow-up (1.14?0.63 / 1.67?1.07 ?m). In group II the respective values started at a higher preoperative level (1.68?1.02 / 2.55?1.33 ?m), increased slightly to he 3 months follow-up (3.35?1.31 / 4.36?1.38 ?m) and decreased continuously over time (1.58?1.10 / 2.71?1.05 µm). In group I, the MAXPEAK was increased at the 3 month postoperative exam (8.78?2.29 ?m) when compared to the preoperative value (4.31?2.02 ?m); however, it decreased again and returned to the preoperative level after one year (6.34?2.12 ?m). In group II, the MAXPEAK was unchanged preoperatively (6.26?2.34 ?m) to the 3 months follow-up, but decreased continuously to the end of the follow-up period (4.49?1.31 ?m). The RMSDEV was significant and correlated inversely with VA preoperatively (R=-0.53, P=0.04 / R=-0.69, P=0.02) and at the 1 year exam (R=-0.61, P=0.02 / R=-0.52, P=0.05) in groups I / group II.

Conclusion: The use of wavelet analysis can provide significant, clinical information by separating the raw data into the parameters: 'roughness', 'waviness', 'form' and various multiscalar peaks and pits. The RMSDEV, a quantitative measure for corneal irregularity, can be used as a new approach for the prediction of potential visual acuity after refractive surgery. The decomposition of the surface elevation into fundamental components is crucial for a subsequent mathematically based extraction of clinical parameters using standard wavefront aberroscopy.

Contact: Achim Langenbucher, PD Dr., Augenklinik mit Poliklinik der Universität Erlangen Nürnberg, Schwabachanlage 6, D-91054 Erlangen, Germany;
E-Mail: Achim.Langenbucher@augen.imed.uni-erlangen.de

Oral Presentations

Session II: Biomechanics and optic

FLAP INDUCED CHANGES IN THE WAVE ABERRATION IN LASIK

(Jason Porter, Geunyoung Yoon, Scott MacRae, Ian G. Cox, Cynthia J. Roberts, David R. Williams)

Purpose: To study the changes in the monochromatic wave aberration induced by the process of cutting a corneal flap in a sample of normal human eyes. A better understanding of how the corneal biomechanics are altered by the microkeratome incision could improve the predictability of a conventional LASIK procedure.

Methods: A corneal flap was cut using a microkeratome (Hansatome) in only one eye of each patient and no subsequent laser ablation was performed. A wavefront sensor (Zywave) was used to measure the wave aberration for each patient before the flap cut, immediately after the cut, and at 1-day, 1-week, 1-month and 2-months post-flap cut over a 6 mm pupil. Anterior and posterior corneal surfaces were also measured using a corneal topographer (Orbscan II). Zernike coefficients for the cornea were calculated based on each corneal surface's elevation data.

Results: Across patients, the rms of the higher order aberrations in the flap eyes increased, on average, at the 2-month post-flap cut visit. Patients showed a slight tendency toward a hyperopic shift and spherical aberration had a small, systematic increase, on average, by approximately 20% across patients. However, there was an extremely wide variation in the response of individual Zernike modes across patients after cutting a flap.

Conclusion: The process of cutting a corneal flap with a microkeratome increases the eye's higher order aberrations in a non-systematic fashion across patients. Even though there is a slight tendency for spherical aberration to increase across patients, this increase does not fully account for the typical amounts of spherical aberration that are induced in post-LASIK patients. In addition, some compensatory aberration changes were observed in the posterior cornea. However, most of the aberrations induced by the flap cut arise from changes in the anterior cornea, due to the large refractive index difference between the cornea and air.

Contact: Jason Porter, BS, MS, Center for Visual Science, Meliora 274, University of Rochester, Rochester NY 14627, USA;
phone: (716) 275-8143; fax: (716) 271-3043; E-Mail: jporter@optics.rochester.edu

Session IX: Optical aberrations and vision (free papers)

THE EFFECT OF AGING ON SCATTERING AND HIGHER-ORDER ABERRATIONS

(Kuroda Teruhito, Takashi Fujikado, Naoyuki Maeda, Youko Hirohara, Toshifumi Mihashi, Sayuri Ninomiya, Yasuo Tano)

Purpose: To study the effect of the aging on ocular scattering and higher-order aberrations.

Methods: Seventy six eyes of 76 normal subjects who had no ocular diseases except for refractive errors were included. Ages were ranged from 4 to 69 years. Wavefront aberrations for central 4mm diameter were measured using Hartmann-Shack sensor (Wavefront analyzer, Topcon, Japan). Higher-order aberrations were calculated with Zernike polynomials up to 4th order. The amount of scattering was estimated by using width of point-spread functions(PSFs) in the Hartmann image. Width was compensated by the aberrations. Linear regression analysis was performed to investigate the effect of aging on scattering and total higher-order aberrations.ÿ@

Results: Mean and standard deviation of the scattering index and the total higher-order aberrations were 11.30ÿ} 2.4 and 0.11ÿ} 0.04 mmRMS, respectively. A significant correlationÿ@was obtained between scattering and age (Spearman rank correlation coefficient, r= 0.501, p=0.001). Also, total higher-order aberrations (r=0.323, p=0.005) significantly increased with age.

Conclusion: Both scattering and total higher-order aberrations were altered with aging. Scattering correlated with age better than higher order aberrations.

Contact: Kuroda Teruhito, MD, Osaka University Medical School, 2-2, yamadaoka, Suita, J-Osaka 565-0871, Japan; phone: 81-6-6879-3456;
fax: 81-6-6879-3458; E-Mail: kuroda@sensory.med.osaka-u.ac.jp

WAVELENGTH DEPENDENCE OF THE ZERNIKE EXPANSION OF THE WAVEFRONT ERROR IN HUMAN EYES

(Rejean Munger, David Priest, Bruce, W., Jackson)

Purpose: To investigate the wavelength dependence of the zernike wavefront error expansion in the human eye.

Methods: Hartmann-Shack pattern of 10 eyes from 10 nearly emmetropic (less than 1 DS or DC) were obtained at 650, 600 and 550 nm using a filtered Xenon arc lamp. Fifteen consecutive patterns (over 0.5 second) were obtained for each subject at each wavelength. Wavefront maps were calculated and a zernike expansion (4th order) obtained for each pattern. Expansion coefficients from the 15 patterns were averaged and a standard deviation obtained. One way Anovas were used to test for significant changes in defocus (Z[2,0]), spherical aberration (Z[4,0]) and coma (Z[3,-1], Z[3,1]) as a function of wavelength.

Results: In all subjects defocus increased (mean=0.50D, SD=0.24D) between 650 and 550 nm. In 9 of the10 subjects there was a significant ($p<0.05$) difference (4 increased and 5 decreased) in spherical aberration across wavelengths. The 9 patients with significant coma (Z[3,1] or Z[3,-1] > ±0.015) showed a significant change in coma with wavelength. In 8 of these patients, the change in Z[3,-1] is opposite in direction to the change in Z[3,1] and there is a shift of the dominance between the two term at 550 and 650 nm.

Conclusion: Spherical aberration and coma are wavelength dependent. There are general patterns but the amplitude of the changes are subject dependent. Results suggest that wavefronts measured in the infrared might not be accurate when applied to work in the visible.

Contact: Rejean Munger, Ph.D., U. of Ottawa Eye Institute, Ottawa Hospital General Site, 501 Smyth, Ottawa Ontario K1H 8L6, Canada;
phone: 613-737-8547; fax: 613-739-6645; E-Mail: rmunger@ohri.ca

THE QUALITY OF VISION AND WAVEFRONT ABERRATIONS AFTER LASIK
(Steven Schallhorn)

Purpose: To assess quality of vision after LASIK in comparison to wavefront aberrations.

Methods: A quality of vision questionnaire was administered to patients undergoing LASIK for myopia and astigmatism. The questionnaire was administered preoperative and at one month postop to assess glare, haze, and halo disability. Data gathered from the questionnaires was compared to the patient's preoperative and postoperative aberrations using a Hartmann Shack wavefront device.

Results: Several higher order aberrations were correlated with the quality of vision complaints postoperative. For instance, there was a significant correlation with the postop aberration and halo problems (p=0.03). Patient cases will be presented.

Conclusion: Wavefront technology can offer new insights into quality of vision complaints after LASIK. This suggests that wavefront guided ablations, which reduce the level of some higher order aberrations, may improve the quality of vision after LASIK

Contact: Steven Schallhorn, MD, Naval Medical Center, 34800 Bob Wilson Drive, San Diego CA 92134, USA; phone: (619) 532-6702; fax: (619) 532-7272;
E-Mail: scschallhorn@nmcsd.med.navy.mil

Session X: Accommodation and IOL's (free papers)

DYNAMIC WAVEFRONT MEASUREMENTS OF EYES WITH ACCOMMODATIVE IOL
(H. Burkhard Dick, Till Werner, Stefan Kaiser, Julia Wrede)

Purpose: To dynamically and objectively measure the effect of accommodative IOLs using a wavefront aberrometer and to monitor low and high order aberration changes.

Methods: An aberrometer based on Hartmann-Shack principle (WASCA, Asclepion, Germany), which allows the measurement in a sequential mode, took measurements at a frequency of approximately 7 Hz. A sequential aberrometer measurement of the accommodation process was performed in 10 eyes 6 weeks after implantation of a new type of accommodative IOL (1CU, HumanOptics, Germany). The patients initially focused at a distance target (400 cm) for 10 seconds followed by focussing at the near target (35 cm). After additional 10 seconds the distance target was focussed again. During these 30 seconds 200 single wavefront measurements were taken and analyzed. As a reference the same setup was used for phakic eyes and for an eye with a standard IOL.

Results: The measurements of the phakic eyes as well as of the eyes with the accommodative IOL demonstrated a recognizable accommodative effect in sphere, cylinder, spherical equivalent and high order aberrations. The eye with the standard IOL showed no recognizable accommodative effect. For each subject there were substantial, systematic changes in the aberrations that depended on accommodative state.

Conclusion: Accommodation processes and their effects on low and high order aberrations were detected dynamically in phakic eyes as well as after implantation of accommodative IOLs. The new accommodative IOL showed a recognizable accommodative effect including reproducible changes in specific aberrations.

Contact: H. Burkhard Dick, MD, Department of Ophthalmology, Langenbeckstr. 1, Johannes Gutenberg-University, D-55131 Mainz, Germany;
phone: +49-6131-175150; fax: +49-6131-175566; E-Mail: bdick@mail.uni-mainz.de

ABERRATIONS GENERATION BY CONTACT LENSES WITH ASPHERIC AND ASYMMETRICAL SURFACES

(Norberto López-Gil, José Francisco Castejón-Mochón, Antonio Benito, José María Marín, George Lo-a-Foe, Gildas Marin, Bruno Fermigier, Dominique Renard, Denis Joyeux, Nicolas Chateau, Pablo Artal)

Purpose: CLAAS (Contact Lenses with Aspheric and Asymmetric Surface) is a collaborative research project exploring the actual possibilities of ocular high-order aberration correction by using customize contact lenses (CLs). We present here results of aberrations on eyes with a new generation of soft contact lenses with desired aberration profiles manufactured using sub-micron precision lathe technology. The first samples were designed with one asymmetrical surface (front) and one spherical (back) to produce a certain amount (between 0.01 to 1.25 mm for a 5 mm pupil) of astigmatism, trefoil, coma or spherical aberration. The purpose was to test the CLs in twofold: just after being manufactured; and on the human eye.

Methods: First, we measured the wave-front aberration in the CLs samples with a Fizeau interferometer. This provides with the actual aberration pattern that could be different from the design target. Second, we measured the wave-front aberration of the samples when placed in real eyes by subtracting the aberrations of the eye plus CL and those present in the same naked eye. This second set of measurements was obtained using a Shack-Hartmann (S-H) sensor.

Results: Theoretical target values and those finally produced in the CLs after interferometric measurements show the aberration value expected (differences within the SD) except for low aberration smaller than 0.06 mm in some samples, likely indicating some problems in the manufacture process. Moreover, a good matching (errors smaller than 8 %) between the aberration mode values obtained directly in the CL and when the CL was placed on the eye.

Conclusion: This are the first results towards a plausible goal of correcting aberrations using CLAAS, which are specially promising for patients with moderate to high amount of aberrations.

Contact: Norberto López-Gil, Ph.D., Universidad de Murcia, Laboratorio de Óptica. Edificio C., E-30071 Murcia, Spain;
phone: 34-968367222; fax: 34-968363528; E-Mail: norberto@um.es

CORRECTING ON-EYE AND OFF-EYE SPHERICAL ABERRATION IN SOFT CONTACT LENSES

(Holger Dietze, Michael Jude Cox)

Purpose: Spherical aberration (SA) affects the power of a soft contact lens (SCL)on-eye and off-eye. A simple model assuming that the SCL aligns to the cornea predicts that these effects are identical on-eye and off-eye for a wide range of corneal shapes.

Methods: Ray tracing through spherical and aspherical SCLs on-eye and off-eye was performed. Aspheric lenses were designed to minimise SA off-eye. The resulting Zernike-coefficients describing the wavefront aberration for 3mm and 6mm pupils were examined. Effective powers to minimise the variance of wave aberrations were determined.

Results: For a 6mm pupil diameter +/-3.00D spherical SCLs have an effective power of +/-3.25 and +/-7.00D lenses equate to +/-7.50D both on-eye and off-eye. For a 3mm pupil diameter the effective power change is +/-0.15D for a +/-9D SCL. Power change is negligible for aspheric SCLs (<+/-0.01D for all lenses). Wavefront aberration and on-eye SCL surface measurements will be presented to confirm or refute this model of behaviour.

Conclusion: If a SCL aligns to the corneal surface, the effective power of the SCL primarily depends upon the SCL surface asphericity and pupil size but little on the corneal surface characteristics. For higher levels of ametropia the power of aspherical SCLs should be determined with aspherical trial lenses of a similar p-value to the prescribed lens. Future research into the flexure characteristics

Contact: Holger Dietze, MSc in Clinical Optometry, University of Bradford, University of Bradford, Department of Optometry, Bradford BD7 1DP, UK;
phone: 0044-1274-234640; fax: 0044-1274-235570; E-Mail: h.dietze@bradford.ac.uk

DYNAMIC WAVEFRONT REFRACTOMETRY WITH ASCLEPION ABERROMETER IN DIFFERENT LIGHT CONDITIONS

(Sophia I. Panagopoulou, Ioannis G. Pallikaris MD)

Purpose: The Asclepion Wavefront analyzer was used for measuring the accommodation process in a big series of eyes. During the process of accommodation of an eye, we measured the low and the higher order aberrations.

Methods: We examined eyes with no need for glasses or CL (N=60 eyes). The subject was asked to focus at a target in different distances. The procedure of accommodation was measured in full light, mesopic and scotopic conditions. We derived information for the lower and the higher order aberrations of each eye in every stage of the accommodation procedure.

Results: From the evaluation of the results there is a statistical significant difference ($p<0.001$) for some of the Zernike coefficients during accommodation and in different light conditions. The differences are also influenced from the age and the refraction of the eyes measured.

Contact: Sophia I. Panagopoulou, PhD, University of Crete, Medical School, Medical School, Heraklion 71110, Crete, Greece;
phone: +3081394645; fax: +3081394653; E-Mail: spanagop@med.uoc.gr

DYNAMIC WAVEFRONT REFRACTOMETRY WITH ASCLEPION ABERROMETER IN THE ACCOMMODATION PROCESS

(Ioannis G. Pallikaris, Sophia I. Panagopoulou)

Purpose: To analyze dynamically the process of accommodation using the Asclepion Wavefront Aberrometer.

Methods: In this study we examined 10 eyes. A sophisticated accommodation stimulus was used to measure accommodation in different distances (from far to near). The accommodative eye was recorded continuously while the subject is focused on a moving target. The Wavefront accommodation response is presented during time. We derived information for the lower and the higher order aberrations of each eye in every stage of the accommodation procedure and for center as well as for the periphery of the pupil measured.

Results: From the evaluation of the results there is a statistical significant difference ($p<0.001$) for spherical and coma (always changing with the same way) during accommodation. There is a continuous change in the sphere and high order aberrations with a periodicity and homogeneity during time of fixation. This phenomena are more intensive in the near target fixation. Time of stabilization from far to near and opposite, was also recorded and there is an influence from the age and the refraction of the eyes measured.

Conclusion: The procedure of accommodation can be measured dynamically revealing very important information for the role and the contribution of the aberrations during this process.

Contact: Ioannis G. Pallikaris, MD, PhD, University of Crete, Medical School, Heraklion 71110, Crete, Greece;
phone: +3081392450; fax: +3081394653; E-Mail: ophadmin@med.uoc.gr

Session XI: Adaptive optics and applications in eye care

WAVEFRONT-TECHNOLOGY AND ADAPTIVE OPTICS:THE HEIDELBERG APPROACH
(Josef Bille)

Purpose: Research and development work on wavefront technology and adaptive optics was initiated at the University of Heidelberg in the 1970's. The initial applications were concerned with imaging of astronomical objects through the turbulent atmosphere.Soon,aberration-free imaging of the human eye was invented.

Methods: The initial applications were concerned with aberration-compensated imaging of the retina of the human eye with laser scanning imaging systems. In the 1980's, Hartmann-Shack sensors were for the first time applied to objectively assess the aberrations of the human eye.

Results: More recently, the technique of Hartmann-Shack-type sensors was augmented by incorporating multiple micromirror devices, allowing for an improvement in spatial resolution by two orders of magnitude and dynamic compensation of all aberrations of the human eye with real time resolution.

Conclusion: The results of studies on normal and highly aberrated eyes demonstrate an excellent correspondence to prior simulation studies. Special considerations are adviced with regard to the selection of optimal optical stimuli and resolution targets for optimizing the subjective appreciation of aberration-free vision.

Contact: Josef Bille, PhD, University of Heidelberg, Kirchhoff Institute of Physics, Albert-Ueberle-Strasse 3-5, D-69120 Heidelberg, Germany; phone: 49-6221-549251; fax: 49-6221-549262; E-Mail: josef.bille@kip.uni-heidelberg.de

DECONVOLUTION OF ADAPTIVE OPTICS RETINAL IMAGES
(Julian C. Christou, Austin Roorda, David R. Wiiliams)

Purpose: Adaptive optics imaging of the retina produces clearer images of the cone photoreceptors. However, the AO point spread function is not perfectly corrected and the residual aberrations, which are non-stationary, affect radiometric (i.e. densitometry) and retinal-structure measurements.

Methods: We have applied deconvolution techniques to remove and reduce the effects of the residual blur. A number of deconvolution techniques exist when a PSF is measured simultaneously to the data. For the data presented here, we do not have such a PSF and use a proven.

Conclusion: Post-processing represents a powerful and economical addition to AO retinal imaging. It has the potential to make more efficient use of radiometric measures of photopigments and to push further the limits of detection and resolution of retinal structure.

Contact: Julian C. Christou, Ph.D., Center for Adaptive Optics, University of California, 1156 High Street, Santa Cruz CA 95064, USA;
phone: 831 459-5775; fax: 831 459-5717; E-Mail: christou@ucolick.org

ADAPTIVE OPTICS VISUAL SIMULATOR

(Pablo Artal, Enrique J. Fernández, Silvestre Manzanera and Patricia Piers)

Purpose: To develop a prototype based on adaptive optics technology to produce the desired amount of aberrations in a subject's eye. The device will also be capable of measuring the subject's spatial vision for each controlled aberration profile. This

Methods: The apparatus uses infrared light to measure the wave-front aberration of the system plus the eye at video rate (25 Hz) with a Hartmann-Shack sensor. Defocus is added (or removed) by a computer-controlled motorized optometer while higher order aberrations are produced by a membrane deformable mirror with 37 channels. An additional viewing channel is used for visual testing through the device. Visual acuity, contrast sensitivity and other visual tests are performed under normal viewing for each desired aberration profile.

Results: The adaptive optics visual simulator allows for the production of the desired aberration pattern in subjects under normal viewing conditions. The range of defocus production is nearly unlimited (as produced with the motor). The maximum amount of other aberration modes is restricted to approximately 1 micron, depending on which mode. Pure modes or any selected combination of modes can be produced with high repeatability and precision (usually better than 0.05 microns). The system works accurately for pupil diameters up to 6 mm in diameter (with natural pupil). The current version of the visual simulator still requires precise alignment of the subject's pupil with the deformable mirror but the device is robust enough to allow for blinking, which renders the simulator valid for long visual testing.

Conclusion: We built a prototype, that we called adaptive optics visual simulator, that produces virtually any desired aberration pattern within the eye while the subject comfortably performs visual tasks. The simulator is a powerful, non-invasive, tool to further evaluate how aberrations affect vision. Future findings could greatly benefit new ophthalmic designs or wave-front guided refractive surgery.

Contact: Pablo Artal, Ph.D., Universidad de Murcia, Laboratorio de Optica, Campus de Espinardo (Ed. C), E-30071 Murcia, Spain;
phone: 34 968367224; fax: 34 968363528; E-Mail: pablo@um.es

VISION PERFORMANCE TESTING WITH THE LAWRENCE LIVERMORE ADAPTIVE OPTICS SYSTEM

(Charles Thompson, Robert M. Sawvel, Dennis A. Silva)

Purpose: To explore the limits of human visual acuity using a diffraction-limited Adaptive Optics System.

Methods: This AO system is based on a Liquid Crystal Spatial Light Modulator (SLM) having over 200,000 (480 x 480) degrees of freedom, and utilizes a 300 spot (20 x 20) Hartmann-Shack sensor, allowing for diffraction limited correction of the aberrations in the human eye.

Results: Initial results will be presented at the talk.

Conclusion: LLNL has developed an Adaptive Optics system useful in correcting high-order ocular aberrations. Initial use of this system is to explore the limits of human visual acuity. Modifications to this system may make it useful for retinal imaging studies.

Contact: Charles Thompson, PhD, Lawrence Livermore National Laboratory, L-290, PO Box 808, Livemore CA 94551, USA;
phone: (925) 423-5907; fax: (925) 422-1796; E-Mail: charlest@llnl.gov

Session XII: Basics of Customized treatments (free papers)

EPITHELIAL AND BIOMECHANICAL CONSIDERATIONS MAY BE REQUIRED FOR ACCURATE WAVEFRONT GUIDED ABLATIONS

(Dan Z Reinstein)

Purpose: To determine to what extent epithelial and biomechanical changes in LASIK may affect LASIK and hence wavefront guided customized corneal ablation.

Methods: 52 myopic LASIK treatments (-1.00 to -10.25) were analyzed by 3D very high-frequency (VHF) digital ultrasound scanning (1-µm precision) and Orbscan before and at least 3-month post-op. Corneal power shifts due to epithelial changes and biomechanical changes were quantified. The relative contribution of each effect was independently studied to determine their relative contribution to the observed post-operative refractive change.

Results: The post-operative refractive error was correlated to the amount of measured epithelial power shift ($p<0.05$, $R=0.29$) with average 0.25D of epithelial power shift per diopter of refractive error post-op. Post-operative refractive error was highly correlated with borderline significance to residual stromal thickness (RST) ($p=0.056$, $R=0.7$) for cases with RST below 290-microns. Fifteen percent of the flattening produced by ablation was lost to "bowing" of the cornea. Five percent of flattening produced by ablation was lost to epithelial profile changes.

Conclusion: Notable biomechanical and epithelial effects were demonstrated. For accurate wavefront guided ablations, biomechanical and epithelial healing effects may need to be accounted for.

Contact: Dan Z Reinstein, MD FRCSC, Reinstein Institute, 15 Sydney House, Woodstock Rd, London W4 1DP, UK; phone: 011 44 20 8994 2890;
fax: 1 413 416 5956; E-Mail: danreinstein@compuserve.com

WIDE-FIELD COMPENSATION OF MONOCHROMATIC EYE ABERRATIONS: DESIGN TRADE-OFFS AND PERFORMANCE LIMITS

(Salvador Bará, Rafael Navarro)

Purpose: Monochromatic eye aberrations change across the visual field. Although the overall image quality of typical human eyes varies only slowly for fields up to about 10º, this relative constancy arises from a delicate balance among individual aberration terms, which may vary themselves in a more pronounced way. An exact compensation of on-axis aberrations leads to a less-than-optimum image quality in neighbouring field regions. In this work we analyze this effect and develop some calculation procedures to design wide-field correcting elements.

Methods: The wave aberration of the eye is expanded as a series of orthogonal functions, e.g. Zernike polynomials, with coefficients dependent on the direction across the field. Metrics of image quality are based on the residual wavefront variance after correction. Optimum coefficients for optically thin correcting elements
are calculated using linear minimization techniques.

Results: This approach allows to compute the phase profile of elements having specific useful properties. In particular, elements minimizing the residual rms aberration in a given field region, and elements providing a maximum uniformity in image quality over that region are proposed. Their expected performance is analyzed using on- and off-axis human eye aberrations measured by Laser Ray Tracing.

Conclusion: Guidelines for computing the phase profile of several kinds of optically thin wide-field aberration correcting elements are provided. These results may be applied as a starting point in the design of wide-field high-resolution retinal imaging devices, ophtalmic lenses and customized refractive surgery procedures. (Work supported by the Spanish CICYT, grant TIC98-0925-C02)

Contact: Salvador Bará, Ph.D., University of Santiago de Compostela, Area de Optica, Dpto. Fisica Aplicada, Fac. Fisica, Campus Sur, E-15782 Santiago de Compostela, Spain;
phone: +34 981 563100; fax: +34 981 590485; E-Mail: bara@usc.es

LIMITATIONS OF WAVEFRONT-CORRECTIONS WITH A SCANNING SPOT LASER SYSTEM.

(Maik Kaemmerer, Michael Mrochen)

Purpose: A worldwide run on wavefront technology started some years ago. By using scanning spot laser sytems one might be able to correct the measured wavefront aberrations of the human eye to eventually increase the visual ability. But, besides others, this technology raises two questions: Is it really possible to completely correct higher order wavefront aberrations with a scanning spot laser system and, if so, what laser parameters are needed to do that? The goal of this study was to find answers to these important questions.

Methods: Ablation profiles from single Zernike-coefficients up to the 8th order were calculated for optical zones of 6mm. To fill single laser pulses into each of these profiles an optimized random-based algorithm were used. The diameter of these pulses varied between 0.5, 1.0 and 1.5 mm and the ablation depth per pulse between 0.125, 0.25 and 0.5 microns. Two different laser pulse shapes were investigated: gaussian beam and top-hat-profile. By subtracting the filled profiles (real laser profiles) from the single-Zernike-profiles (ideal profiles) error maps for each correction were available. Finally the rms-values of these error-maps and the ideal profiles were calculated and compared.

Results: Corrections of higher order optical aberrtions can not be done with a top-hat beam profile (rms-reduction < 50% in some cases). With a gaussian beam and a diameter of 1.5mm it is only possible to correct wavefront-errors up to the 4th order with high accuracy (rms-reduction > 90%). Corrections of optical aberrations up to the 6th order require a 1mm gaussian beam with a minimal ablation depth per pulse (rms-reduction > 90%). Wavefront-errors up to the 8th cannot be corrected even with the smallest ablation volume per pulse (rms-reduction < 90% for all parameters).

Conclusion: This theroetical study showed that all of the scanning spot systems on the market cannot completely correct higher order optical aberrations. Including errors induced by the laser and scanning mirrors the result gets even worse. Best results for corrections of optical aberrations up to the 6th order were optained with 1mm gaussian beam. Even these systems will produce an error in the order of 10%. The only way to increase the accuracy of the corrections is to reduce the ablation volume per pulse. This requires excimer laser systems with higher repetition rates (500Hz, 1000Hz) to reduce surgery duration. The future will show if such a system can be adapted to the human eye.

Contact: Maik Kaemmerer, Dipl.-Ing., mikrolab GmbH, Siemensstr.43,
D-90766 Fürth, Germany; phone: +49 911 9659930;
fax: +49 911 9659950; E-Mail: m-kaemmerer@mikrolab.com

CAN OCULAR CYCLOPOSITIONAL CHANGE BETWEEN ERECT AND SUPINE BODY POSITION AFFECT THE OUTCOME OF ABERRATION-FREE REFRACTIVE CORRECTION?

(Hermann Dieter Schworm, Tony Pansell, Roswitha Gordes, Roberto Bolzani, Franz Fankhauser, Jan Ygge)

Purpose: To assess the amount of ocular cycloduction induced by change of body position from erect to supine and by changing from monocular to binocular viewing condition. Cyclopositional changes could influence the outcome of aberration-free refractive correction by creating a wrong astigmatic axis.

Methods: Eye movement recordings were performed using the video-oculography technique

Conclusion: Our results demonstrate that a considerable amount of cycloduction can be induced by change of body position and thus torsional errors between wave front sensing while erect and refractive correction while supine can occur. Depending on the amount of astigmatism and aberrations of higher degrees it seems plausible that the visual outcome could be affected by uncorrected torsional changes.

Contact: Hermann Dieter Schworm, Prof. Dr., University Eye Hospital Hamburg, Martinistrasse 52,
D-20246 Hamburg, Germany; phone: +49-40-42803-6838;
fax: +49-40-42803-3067; E-Mail: schworm@uke.uni-hamburg.de

EFFECT OF CORNEAL DECENTRATION ON THE OUTCOME OF LASER REFRACTIVE SURGERY PROCEDURE

(Geunyoung Yoon, Christopher Kwon, Scott MacRae, Jason Porter, Ian Cox, David Williams)

Purpose: To understand the effect of corneal decentrations on the outcome of eyes undergoing laser refractive surgery and to evaluate how fast an eye tracker is needed to remove decentration effects from customized laser ablation.

Methods: A pupil camera that has a maximum sampling rate of 30Hz was used for monitoring corneal decentrations during a conventional laser refractive surgery procedure without an eye tracker. The measurement accuracy of the decentration was 0.11mm in both the horizontal and vertical directions. From these data, we computed the temporal power spectrum for 5 patients (9 eyes). A Shack-Hartmann wavefront sensor and corneal topographer were used to measure changes in the eye's total aberration and in corneal surfaces that were compared with the simulation results.

Results: At a 30Hz sampling rate, the mean +/- standard deviation of the eye movement from the center axis was -0.003 mm +/- 0.247 mm and 0.047mm +/- 0.193 mm in the horizontal and vertical directions, respectively. The mean magnitude of the eye movement was 0.19 and 0.15 mm in each direction. The temporal spectra in both directions are similar. The power of the decentration up to 1Hz included approximately 96% of total power of the decentration, on average, in both directions.

Conclusion: Eye movements seem to be roughly distributed around the central axis in both the directions. Based on our data at a 30Hz sampling rate, an eye tracking system with a 1Hz closed-loop bandwidth could compensate for most corneal decentrations. The eye movement data can be used to estimate the aberrations induced by decentration and influence on retinal image quality.

Contact: Geunyoung Yoon, Ph.D., Department of Ophthalmology, University of Rochester, Rochester NY 14627, USA;
phone: 716-273-4998; fax: 716-271-3043; E-Mail: yoon@cvs.rochester.edu

ICT - INTRAOPERATIVE CORNEAL TOPOGRAPHY FOR IMAGE REGISTRATION PURPOSES

(Stephan Schruender)

Purpose: To present a reliable method to register corneal images for alignment purposes.

Methods: High resolution corneal topographies with an accuracy in the micrometer range were taken of porcine eyes using an ultraviolet fringe projection method. Random and controlled movements (transversal and rotational) were performed to mimic real life situations during refractive surgery. Topographies were registered using an ICP (iterative closest point) algorithm which is derived from other 3d measurement applications. Simulations representing the same situation were also performed.

Results: Corneal topographies were registered with an accuracy of better than 10 microns peak to valley (PV) and 3 microns root mean square (RMS). Simulations with different noise and contrast levels in the original fringe images confirmed these results.

Conclusion: A new method to register corneal topographies is presented. The method is applicable during refractive surgeries which allows for an accurate alignment of the ongoing treatment with considerably higher accuracy than with currently available eye trackers. It will also enable a precise correlation between locations on the cornea that require individual corrections as diagnosed with wavefront aberrometers beforehand and as actually ablated during the treatment. It will thus increase the precision and reliability of the ablation's centration.

Contact: Stephan Schruender, M.S., BioShape AG, Fregestr. 67, D-12159 Berlin, Germany;
phone: +49 30 6908 8291; fax: +49 30 6908 8040; E-Mail: sas@bioshape.com

CORRECTION OF HIGHER ORDER ABERRATIONS BY ACTIVE PUPIL CONTROL.

(Isaac Lipshitz, Gad Dotan MD, Ronni Levy BA MBA)

Purpose: Improving visual acuity by actively controlling the size of the pupil. Mid peripheral higher order optical aberration of the eye can be considerably reduced by changing the pupil size.

Methods: A new intraocular implant was designed that can regulate the pupil size precisely using an externally operated control.

Results: The implant consists of 4 magnetic elements that are attached to the iris by mini iris-claw elements and can be regulated by an external magnetic field created by a controller thus enabling the patient to change his pupil size according to the hanging environment and visual needs.

Conclusion: Active pupil control will improve the visual performance of the human eye and is essential for achieving supervision.

Contact: Isaac Lipshitz, MD, OPhthalmic Health Center, 40 Einstein St.,
ISR-69101 Tel Aviv, Isarel;
phone: 972 3 6437925; fax: 972 3 6437926; E-Mail: Lipshitz@netvision.net.il

THE REDUCTION OF SPHERICAL ABERRATION WITH THE WAVELIGHT ALLEGRETTO

(Jeffery Machat)

Purpose: To objectively measure and evaluate the degree of spherical aberration induced from LASIK performed with both conventional non-wavefront and wavefront based ablation profiles of the Wavelight Allegretto Wave excimer laser.

Methods: Wavefront analysis with both Tscherning and ray tracing aberrometry was performed on 100 patients who were treated with either conventional non-wavefront or wavefront based ablation software with the Allegretto Wave excimer laser. Post-operative spherical aberration was measured and compared to pre-operative values for each patient at 1 and 3 months. Comparative analysis between the wavefront and non-wavefront treated groups was performed with respect to the induction of spherical aberration.

Results: The mean amount of spherical aberration in the wavefront treated group was 0.19 pre-operatively, reducing to 0.18 post-operatively with some individual patients experiencing a substantial decrease in their degree of spherical aberration. The mean amount of spherical aberration in the non-wavefront based group was 0.18 pre-operatively, rising only slightly to 0.20 post-operatively. The mean change difference was not statistically significant for either group but was statistically significant than controls treated with other laser systems who experienced a two to fivefold increase in their degree of spherical aberration.

Conclusion: The Wavelight Allegretto Wave excimer laser system using wavefront guided ablations was highly effective at reducing the degree of induced spherical aberration from LASIK refractive surgery. The conventional non-wavefront based internal laser algorithm also targets a more prolate post-operative cornea and both effectively preserve low light contrast sensitivity and quality of night vision.

Contact: Jeffery Machat, MD, TLC Laser Center Inc., 181 Bay Street, Suite 150, Toronto Ontario M5J 2T3, Canada;
phone: 248-360-7601; fax: 248-360-7602; E-Mail: jeff.machat@tlcvision.com

LASEK AND LASIK COMPARATIVE WAVEFRONT ABERROMETRY RESULTS IN MYOPIA AND HYPEROPIA WITH AND WITHOUT ASTIGMATISM

(Daniel Durrie, Paul M Petelin, Jr., Ethan E Huisman)

Purpose: To describe initial clinical comparison of wavefront aberrometry for Lasek and Lasik for the treatment of myopia and hyperopia with and without astigmatism

Methods: A retrospective review of in excess of 150 consecutive LASEK cases was completed. Parameters examined include all mean preoperative topographic and refractive data including wavefront analysis. Postoperative course was examined including time to visual recovery, UCVA and BCVA at last follow-up, and postoperative wavefront data. Comparison was then made to a representative cohort of patients treated with LASIK for myopia with and without astigmatism in which wavefront data was available pre- and postoperatively.

Results: Preliminary results show that Lasek induces fewer statistically significant higher order aberrations when compared to Lasik. Results of wavefront comparisons will be presented as well as comments on the optical impact of the LASIK flap with examples of flap induced wavefront error. Proper patient selection and education will be stressed.

Conclusion: Our preliminary results are consistent with those recently reported and demonstrate that LASEK offers the opportunity for excellent visual outcomes with the safety and potential optical advantage of avoidance of the LASIK flap. The induction of higher-order wavefront aberrations associated with the LASIK flap will also be addressed. Our experience with patient's safety interests and their overall acceptance of the LASEK procedure has been promising.

Contact: Daniel Durrie, MD, Hunkeler Eye Centers, 5520 College Blvd Ste 200, Overland Park KS 66211, USA;
phone: 913-491-3737; fax: 913-491-9650; E-Mail: ddurrie@novamed.com

Wavefront-guided ablation with MEL 70

(Klaus Ditzen)

Purpose: To evaluate the efficacy of customized ablations using a wavefront-based system for LASIK and PRK.

Methods: 6 eyes of 6 patients have been treted using a wavefront analyzer for diagnostic analysis.After the analysis .These eyes were treated after calculations with the special WASCA-software with the Asclepion-Meditec MEL 70 for LASIK and PRK.

Results: 80% of all eyes gained best corrected visual acuity using WASCA treatments in LASIK but better in PRK.

Conclusion: Wavefront-guided LASIK are feasible apprroaches to correct vision problems .PRK results seemed to be better as primary LASIK results.

Contact: Klaus Ditzen, M.D., Eye-Surgery-Center, Bismarckstr. 4,
D-69469 Weinheim, Germany;
phone: 0049-6201-12026; fax: 0049-6201-183610; E-Mail: kditzen@aol.com

RESULTS OF WAVEFRONT-GUIDED LASIK WITH THE WAVELIGHT ALLEGRETTO WAVE EXCIMER LASER

(Arthur Cummings)

Purpose: To ascertain the safety and efficacy of wavefront guided LASIK with the Wavelight Allegretto Excimer Laser and the Wavefront Analyser

Methods: Retrospective analysis of first 60 wavefront guided LASIK procedures. Visual results as well as wavefront maps were studied

Results: Visual acuities were excellent with ± 40% gaining lines. Higher order aberrations were only slightly increased (up to 20%) or even reduced

Conclusion: Wavefront-guided LASIK was very successful in this group of patients and has become the treatment of choice in many of our patients

Contact: Arthur Cummings, FRCSEd, Wellington Ophthalmic Laser Clinic, 2A Wellington Road, Ballsbridge, Dublin Co. Dublin D4, Ireland;
phone: +353-1-6608821; fax: +353-1-6602816; E-Mail: abc@woclinic.iol.ie

ALLEGRETTO WAVEFRONT GUIDED LASIK - 3 MONTH RESULTS

(Matthias Maus)

Purpose: To evaluate the visual outcome and the change in aberrations 3 months after wavefront guided Lasik.

Methods: 50 eyes which underwent WG-LASIK whith the WaveLight Allegretto were measured with the Tscherning Aberrometer from WaveLight. Measurements were taken up to the 6th order of aberrations. Pre- and postop aberrations were compared to evaluate the amount of induced and corrected aberrations. Visual acuity and target proximity were also measured.

Results: Analyzed data will be presented at the congress

Conclusion: Current technology for WG-LASIK is a step forward to achieve results of higher optical quality for the patients eye. Further steps are necessary to develop the potential of this method.

Contact: Matthias Maus, M.D., Maus & Heiser, Brückenstr. 1-3, D-50667Köln, Germany; phone: +49-221-860 1661; fax: +49-221-860 1699;
E-Mail: matthias@augenzentrum.de