Refractive Surgery Subspecialty Day 2019

As Far as the Eye Can See

Program Directors

Marcony R Santhiago MD and George O Waring IV MD

The Annual Meeting of the International Society of Refractive Surgery (ISRS)

Sponsored by the ISRS

Moscone Convention Center
San Francisco, California
Friday, Oct. 11, 2019

Presented by:
The American Academy of Ophthalmology

Cover photo courtesy of William B Trattler MD

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Refractive Surgery 2019 Planning Group

Marcony R Santhiago MD
Program Director

George O Waring IV MD
Program Director

John So-Ming Chang MD
Burkhard Dick MD
Daniel S Durrie MD
J Bradley Randleman MD
William B Trattler MD

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2009	Gustavo E Tamayo MD Ronald R Krueger MD
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2005	Jorge L Alió MD PhD Steven E Wilson MD
2004	John A Vukich MD Jorge L Alió MD PhD
2003	Terrence P O'Brien MD John A Vukich MD
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2001	Douglas D Koch MD Daniel S Durrie MD
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1999	Marguerite B McDonald MD Richard L Lindstrom MD
1998	Peter J McDonnell MD Marguerite B McDonald MD
1995–1997	Peter J McDonnell MD

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2019 Refractive Surgery Subspecialty Day Planning Group

On behalf of the American Academy of Ophthalmology and the International Society of Refractive Surgery, it is our pleasure to welcome you to San Francisco and **Refractive Surgery 2019: As Far as the Eye Can See**, the Annual Meeting of the International Society of Refractive Surgery.

Marcony R Santhiago MD
Program Director

Alcon Laboratories, Inc.: C,L
Ziemer: C

George O Waring IV MD
Program Director

ACE Vision: C
AcuFocus, Inc.: C,L
Alcon Laboratories, Inc.: C,L
Allergan: C,L
Avedro: C,L
Bausch + Lomb: C,L
GlassesOff: C
Glaukos Corp.: C,L
Ivantis: C
Johnson & Johnson Vision: C,L
Oculus, Inc.: C,L
Omega Ophthalmics: C
Omeros: C
Perfect Lens, LLC: C
Refocus Group, Inc.: C
Riechert: C | SRD Vision: C
Strasthpey Crown: O
Visiometrics: C,O

Planning Group

John So-Ming Chang MD
Alcon Laboratories, Inc.: L
Carl Zeiss, Inc.: L
Hongkong Global Vision Ltd.: S,L
Johnson & Johnson: L

Burkhard Dick MD
Allergan, Inc.: L
Avedro, Inc.: C
Bausch + Lomb: L
Carl Zeiss Meditec: C
Johnson & Johnson Vision: C
Johnson & Johnson: L
Oculus Surgical, Inc.: P
Oculus, Inc.: L
Optical Express AG: C
Polytech-Domilens GmbH: C
RxSight Inc.: C

Daniel S Durrie MD
AcuFocus, Inc.: C,O
Alcon Laboratories, Inc.: C
Alphaeon: O
Avedro: C,L,O
Concierge Key Health: O,C
Eyegate Pharma: C
Hoopes Durrie Rivera Research Center: C
iOR Holdings: O
iOR Partners: O
Johnson & Johnson Vision: C,L
Strathspey Crown LLC: O

J Bradley Randleman MD
None

William B Trattler MD
Abbott Medical Optics: C,L
Alcon Laboratories, Inc.: C
Allergan, Inc.: C,L,S
Alphaeon: O
ArcSCan: O
Avedro: C,L,O
Bausch + Lomb: C,L
CXLO: C,O
CXLUSA: C | EyeVance: C
Guardian Health: C,O
Healthe: O
Iantech: C,O
Kala: C,L | LensAR: C
Oculus, Inc.: L
Shire: C,L | Sun: C,L
True Vision: C,O
Vmax Vision: C

2019 Subspecialty Day Advisory Committee

Daniel S Durrie MD, Chair (Refractive Surgery)
AcuFocus, Inc.: C,O
Alcon Laboratories, Inc.: C
Alphaeon: O
Avedro: C,L,O
Concierge Key Health: O,C
Eyegate Pharma: C
Hoopes Durrie Rivera Research Center: C
iOR Holdings: O
iOR Partners: O
Johnson & Johnson Vision: C,L
Strathspey Crown LLC: O

Maria M Aaron MD (Secretary for Annual Meeting)
None

Julia A Haller MD (Retina)
Aura Biosciences: C
Celgene: O | KalVista: C
Lowy Medical Research Institute: C
Novartis Pharmaceuticals Corp.: C

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Evolvemed: C
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Quark Pharmaceuticals: S
Springer: P
Uptodate: P | Vindico: C

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National Eye Institute: S

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None

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Alcon Laboratories, Inc.: C
Allergan: C
Belkin Laser Ltd.: C
Glaukos Corp.: C
Graybug: C
InjectSense: C | Ivantis: C
Johnson & Johnson: C
Mynosys: C
National Eye Institute: S
Novartis Institute for Biomedical Research: C
Ocular Therapeutix, Inc.: C
Santen, Inc.: C | Shire: C
Thieme Medical Publishers: C
U.S. Food and Drug Administration: C,S

AAO Staff

Ann L'Estrange
None

Melanie Rafaty
None

Debra Rosencrance
None

Beth Wilson
None

Refractive Surgery 2019 Contents

CME Credit

The Academy's CME Mission Statement

The purpose of the American Academy of Ophthalmology's Continuing Medical Education (CME) program is to present ophthalmologists with the highest quality lifelong learning opportunities that promote improvement and change in physician practices, performance, or competence, thus enabling such physicians to maintain or improve the competence and professional performance needed to provide the best possible eye care for their patients.

2019 Refractive Surgery Subspecialty Day Meeting Learning Objectives

Upon completion of this activity, participants should be able to:

- Evaluate the latest techniques and technologies in refractive surgery, specifically the latest and emerging techniques and technologies in cornea biomechanics, cornea imaging, IOL calculations, and ectasia detection
- Identify the current status and future of femtosecond laser, excimer laser, inlay, intracorneal ring segment, crosslinking, and IOL refractive surgery
- Compare the pros and cons of various lens- and corneal-based modalities, including presbyopic and toric IOLs
- Describe the increasing importance of refractive surgery in any ophthalmology practice and the reasons to consider this subspecialty to improve patient care

2019 Refractive Surgery Subspecialty Day Meeting Target Audience

The intended audience for this program is comprehensive ophthalmologists; refractive, cataract, and corneal surgeons; and allied health personnel who are performing or assisting in refractive surgery.

Teaching at a Live Activity

Teaching instruction courses or delivering a scientific paper or poster is not an *AMA PRA Category 1 Credit*™ activity and should not be included when calculating your total *AMA PRA Category 1 Credits*™. Presenters may claim *AMA PRA Category 1 Credits*™ through the American Medical Association. To obtain an application form, please contact the AMA at www.ama-assn.org.

Scientific Integrity and Disclosure of Conflicts of Interest

The American Academy of Ophthalmology is committed to ensuring that all CME information is based on the application of research findings and the implementation of evidence-based medicine. It seeks to promote balance, objectivity, and absence of commercial bias in its content. All persons in a position to control the content of this activity must disclose any and all financial interests. The Academy has mechanisms in place to resolve all conflicts of interest prior to an educational activity being delivered to the learners.

Control of Content

The American Academy of Ophthalmology considers presenting authors, not coauthors, to be in control of the educational content. It is Academy policy and traditional scientific publishing and professional courtesy to acknowledge all people contributing to the research, regardless of CME control of the live presentation of that content. This acknowledgement is made in a similar way in other Academy CME activities. Though coauthors are acknowledged, they do not have control of the CME content and their disclosures are not published or resolved.

2019 Refractive Surgery Subspecialty Day CME Credit

The American Academy of Ophthalmology is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide CME for physicians.

The Academy designates this live activity for a maximum of 7 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Attendance Verification for CME Reporting

Before processing your requests for CME credit, the Academy must verify your attendance at AAO 2019 and/or Subspecialty Day. Badges are no longer mailed before the meeting. Picking up your badge onsite will verify your attendance.

Badge Scanning and CME

Getting your badge scanned does not automatically grant CME credit. You still need to record your own educational activities.

NOTE: You should claim only the credit commensurate with the extent of your participation in the activity.

CME Credit Reporting

Onsite, you can report credits earned during Subspecialty Day and/or AAO 2019 at CME Credit Reporting kiosks located in South Lobby, West Lobby, and the Academy Resource Center, West, Booth 7337.

Registrants whose attendance is verified at AAO 2019 receive an email on **Monday, Oct. 14,** with a link and instructions on how to claim credit online. Attendees can use this link to report credits until **Wednesday, Oct. 30**.

Starting **Thursday, Nov. 14**, attendees can claim credits online through the Academy's CME web page, aao.org/cme-central.

Academy Members

The CME credit reporting receipt is not a CME transcript. CME transcripts that include AAO 2019 credits entered at the American Academy of Ophthalmology's annual meeting will be available to Academy members through the Academy's CME web page beginning **Thursday, Nov. 14**.

The Academy transcript cannot list individual course attendance. It will list only the overall credits claimed for educational activities at Subspecialty Day and/or AAO 2019.

Nonmembers

The Academy provides nonmembers with verification of credits earned and reported for a single Academy-sponsored CME activity. To obtain a printed record of your credits, claim CME credits onsite at the CME Credit Reporting kiosks. Nonmembers choosing to claim credits online through the Academy's CME web page after **Thursday, Nov. 14**, will have one opportunity to print a certificate.

Proof of Attendance

The following types of attendance verification are available during AAO 2019 and Subspecialty Day for those who need it for reimbursement or hospital privileges, or for nonmembers who need it to report CME credit:

- CME credit reporting/proof-of-attendance letters
- Onsite registration receipt
- Instruction course and session verification

You must have obtained your proof of attendance at the CME Credit Reporting kiosks onsite, located in South Lobby, West Lobby, and the Academy Resource Center, West, Booth 7337.

2019 Award Winners

José I Barraquer Lecture and Award

The José I Barraquer Lecture and Award honors a physician who has made significant contributions in the field of refractive surgery during his or her career. This individual exemplifies the character and scientific dedication of José I Barraquer MD—one of the founding fathers of refractive surgery.

Barraquer Award—Prof. Noel Alpins

Noel Alpins AM

Professor Noel Alpins AM has been specializing in cataract and refractive surgery since founding NewVision Clinics in Melbourne in 1996. He speaks widely on these topics at Australian national and international meetings. He has developed new techniques for treating and analyzing astigmatism, known as the Alpins Method, which a peer-reviewed journal published, and he has developed the ASSORT array of surgical management computer programs for vector planning and analysis of treatment. His book *Practical Astigmatism: Planning and Analysis* was published by SLACK in September 2017.

Noel is an honorary clinical professor at the University of Melbourne, Department of Ophthalmology. He is on the editorial board of several ophthalmic information magazines and peer-reviewed journals. He has contributed over 150 articles in peer-reviewed journals and ophthalmic information magazines, as well as more than 20 book chapters. In 2015 he received the Certificate for Outstanding Contribution in Reviewing awarded by Elsevier.

He is a member of the International Intraocular Implant Club (IIIC). He is also a recipient of the 2012 International Society of Refractive Surgery (ISRS) Lans Distinguished Award at the Annual Meeting in Chicago, and in 2013 he received the American Academy of Ophthalmology (AAO) Achievement Award and in 2014 the ISRS Lifetime Achievement award for his internationally recognized contributions to the advancement of refractive surgery over his career.

In 2017, Prof. Alpins was awarded the Member of General Division of Order of Australia AM Honour for his significant service to ophthalmology, particularly to the development of innovative refractive surgery techniques, and to professional associations. He also presented the invited Gregg Lecture at the Annual Scientific Congress of the Royal Australian and NZ College Ophthalmologists in Perth.

Casebeer Award

The Casebeer Award recognizes an individual for his or her outstanding contributions to refractive surgery through nontraditional research and development activities.

Casebeer Award—Dr. Rohit Shetty

Rohit Shetty, MBBS

Dr. Rohit is a cornea-refractive surgeon and a clinician scientist with keen interest in keratoconus and corneal ectatic disorders. He has been practicing high volume refractive surgery for 14 years now. Dr. Rohit Shetty completed his residency in ophthalmology at the St. Johns Medical College for the Diplomate of the National Board. Dr. Shetty obtained his FRCS Glasgow, Scotland, United Kingdom in 2006 and is currently an FRCS examiner. He is the Chief Mentor for the Dual Academic Program (PhD & Clinical Fellowship) at Narayana Nethralaya Eye Institute, Bangalore and Maastricht University

Dr Rohit has over 180 publications in peer-reviewed journals and is a reviewer for many indexed journals in the specialty. He is also on the editorial board of the *Journal of Refractive Surgery*. Dr Shetty's work on pain management after photorefractive keratectomy, influence of stromal molecular markers on corneal ectasia and risk scoring systems to predict ectasia after refractive surgery has been well received. With a keen interest in imaging, some of his research includes, waveform analysis of deformation and deflection amplitude in keratoconus, influence of ocular spherical aberration on near and intermediate visual acuity in presbyopic eyes, biomechanics of LASIK Flap and SMILE Cap and corneal tomography in post-refractive surgery ectasia.

Founders' Award

The Founders' Award recognizes the vision and spirit of the Society's founders by honoring an ISRS member who has made extraordinary contributions to the growth and advancement of the Society and its mission.

Founders' Award—Dr. John Chang

John Chang MD

Dr. John Chang was trained in ophthalmology at Jules Stein Eye Institute, UCLA. He then went to the University of California, San Francisco, and did a fellowship there. He is presently the president of the International Society of Refractive Surgery. Dr. Chang is a past president of the Hong Kong Association of Private Eye Surgeons. He is honorary associate professor of the University of Hong Kong and the Chinese University of Hong Kong. Presently the director of the Guy Hugh Chan Refractive Surgery Centre of Hong Kong Sanatorium & Hospital, Dr. Chang has been interested in cataract and refractive surgery for many years. He is clinical instructor for many refractive implants and surgeries, including LASIK, intracorneal rings, conductive keratoplasty, phakic IOLs, and phacoemulsification.

He is on the Executive Committee of the Asia Pacific Association of Cataract and Refractive Surgeons (APACRS). He is on the editorial boards of *Cataract & Refractive Surgery Today*, *EyeWorld* (Asia Edition), *Ocular Surgery News* (APAO Edition), the *Open Ophthalmology Journal*, the *Chinese Journal of Ophthalmology* (CJO), and *EyeNet* (AAO), and he is the chief editor of *EuroTimes* (China Edition). He has also been awarded the Certified Educator Award by the APACRS, the Gold Medal by IIRSI-India, the Distinguished Service Award and Achievement Award by the Asia Pacific Academy of Ophthalmology (APAO), the Casebeer Award and the Founders' Award by the International Society of Refractive Society (ISRS), and the Senior Achievement Award by the American Academy of Ophthalmology. Dr. Chang is also active in research, publishing, and travelling abroad to give lectures as an invited speaker in order to share his knowledge and findings.

Kritzinger Memorial Award

The Kritzinger Memorial Award recognizes an individual who embodies the clinical, educational, and investigative qualities of Dr. Michiel Kritzinger, who advanced the international practice of refractive surgery.

Kritzinger Award—Dr. Marcony R Santhiago

Marcony R Santhiago MD PhD

Marcony R Santhiago graduated in medicine and completed his residency in Rio de Janeiro, followed by a fellowship in refractive surgery at the University of São Paulo, where he also obtained his PhD. Subsequently, he undertook a fellowship in refractive surgery at the Cleveland Clinic from 2009 to 2012. Currently, Dr. Santhiago holds a faculty position as professor of ophthalmology at the University of São Paulo, where he also mentors PhD students, and at the University of Southern California.

He is associate editor of *Journal of Refractive Surgery* and section editor of *Journal of Cataract and Refractive Surgery*. He is also a reviewer of the most prestigious journals in ophthalmology.

Dr. Santhiago is highly committed to teaching refractive surgery. He has published more than 130 international studies and has a particular research interest in risk factors for post-LASIK ectasia, corneal changes, and remodeling after crosslinking and corneal wound healing. In 2016, he founded an international annual theoretical-practical course on refractive surgery entitled "Refrativa R.I.O.," which has been translated into English and Spanish, and he has taught more than 2,000 surgeons from all over the world. In 2017 he published his first book about refractive surgery, with 80 chapters.

Dr. Santhiago has won some of the most prestigious awards in ophthalmology, such as the Troutman Award and the Waring Award, the Recognition Award from the International Society of Refractive Surgery, the Latin America Research Award in Cornea from the Pan-American Association of Ophthalmology, the Achievement Award and the Best Scientific Video Award from the American Academy of Ophthalmology, the Best Paper of Section Award and the Poster Winner Award from the American Society of Cataract and Refractive Surgery, the Gold Medal for contributions in refractive surgery from the Indian Refractive Society, and the Scientific Video Award from the European Society of Cataract and Refractive Surgery.

He is a member of the International Council and of the Cataract and Refractive Surgery Committee of the International Society of Refractive Surgery (ISRS) and is on the board of directors of the Brazilian Society of Cataract and Refractive Surgery (BRASCRS). He is one of the program directors of Refractive Surgery Subspecialty Day, AAO 2019.

Lans Distinguished Lecturer Award

The Lans Distinguished Lecturer Award honors Dr. Leedert J Lans. Given annually, the award recognizes individuals who have made innovative contributions in the field of refractive surgery, especially in the correction of astigmatism.

Lans Award—Dr. Cynthia Roberts

Cynthia Roberts PhD

Cynthia J Roberts PhD serves as director of Research in the Department of Ophthalmology & Visual Science at The Ohio State University, where she also holds the Martha G and Milton Staub Chair for Research in Ophthalmology. She has a cross appointment in the Department of Biomedical Engineering, where she advises students in vision research. She received a Bachelor of Science degree in nursing from the University of Iowa, where she graduated with distinction in 1979. Subsequently, she received a Master of Science degree in 1986 in electrical engineering, and a doctoral degree in biomedical engineering in 1989, both from The Ohio State University.

Dr. Roberts made significant contributions to the basic science of corneal topography in the 1990s, especially related to optimal algorithms for interpretation of response to refractive surgery. She is widely known for her innovative work in the biomechanics of refractive surgery and in the clinical assessment of biomechanics, as well as recognizing the role of biomechanics in measurement error of IOP, specifically after refractive surgery. Roberts has given over 200 national and international invited lectures, has published over 120 papers in peer-reviewed journals, has contributed to more than 20 book chapters, and has co-edited 3 books, on corneal topography, corneal biomechanics, and biomechanics of the eye. She was named to the 2014 and 2018 Power Lists of the Top 100 Most Influential People in Ophthalmology.

Lifetime Achievement Award

The Lifetime Achievement Award honors an ISRS member who has made significant and internationally recognized contributions to the advancement of refractive surgery over his or her career.

Lifetime Achievement Award—Dr. Ronald R Krueger

Ronald R Krueger
MD MSE

Dr. Ronald R Krueger is the McGaw Professor and chairman of the Department of Ophthalmology and Visual Science at the University of Nebraska Medical Center and director of the Stanley M Truhlsen Eye Institute in Omaha, Nebraska, since February 2019. Formerly the medical director of Refractive Surgery at the Cleveland Clinic Cole Eye Institute in Ohio, Dr. Krueger is a renowned ophthalmologic surgeon with more than 30 years of experience in the field of refractive surgery, specifically in excimer and femtosecond laser research and wavefront optics.

In 1982, Dr. Krueger graduated summa cum laude from Rutgers University with a BSEE in electrical engineering, followed by an MSE in bioengineering from the University of Washington in the following year. After receiving his medical training at the UMDNJ -New Jersey Medical School in 1987, he completed a residency in ophthalmology at Columbia Presbyterian Medical Center in New York City in 1991, followed by both a cornea fellowship at the Dean McGee Eye Institute at the University of Oklahoma and a refractive surgery fellowship at the Doheny Eye Institute of the University of Southern California in 1993.Dr. Krueger has performed over 25,000 refractive surgery procedures and has published more than 170 peer-reviewed manuscripts, as well as numerous abstracts, book chapters, and trade journal articles. He is credited with documenting, in 1985, the first physical description of the effects of the excimer lasers on corneal tissue and coauthoring, in 2001, the first book on wavefront customized corneal ablation. He also pioneered the development of femtosecond laser treatment of the crystalline lens and cataracts, leading to the cofounding of LensAR, Inc. in 2004 and the publication, in 2013, of the first textbook on the subject, *Textbook of Refractive Laser Assisted Cataract Surgery (ReLACS).*

Dr. Krueger now teaches as a professor of ophthalmology at the University of Nebraska Medical Center, where he also serves as the chairman and Eye Institute director. He recently served as the president of the International Society of Refractive Surgery in partnership with the American Academy of Ophthalmology (ISRS/AAO) for the years of 2014 and 2015. In addition, Dr. Krueger has served as the associate editor of the *Journal of Refractive Surgery* for the past 25 years, and he has lectured on refractive surgery in more than 45 countries.

Dr. Krueger has received numerous awards, including the National Leadership Award, Castle Connolly America's Top Doctors award in 2005 and 2010, the 2007 Kritzinger Memorial Award of the ISRS/AAO, the 2008 Lans Distinguished Award of the ISRS/AAO, the 2014 Secretariat Award of the AAO, the 2015 Founders Award of the ISRS/AAO, and in 2016, the Life Achievement Award of the AAO. In 2013, his thesis "Ultrashort-Pulse Lasers Treating the Crystalline Lens: Will They Cause Vision Threatening Cataract?" was accepted for membership in the American Ophthalmological Society (AOS), the oldest and most prestigious in U.S. ophthalmology. At AAO 2018, he received the Jose I Barraquer Award and Lecture, which is the most prestigious honor in refractive surgery worldwide.

Waring Memorial Award for a Young Ophthalmologist

The Waring Memorial Award for a Young Ophthalmologist recognizes an ISRS member early in his/her career who has demonstrated a commitment to ISRS, as well as a commitment to the promulgation of knowledge and the practice of refractive surgery. This award honors George O Waring III MD for his commitment to the profession and to ISRS.

Waring Memorial Award—Dr. Alain Saad

Alain Saad MD

Dr Alain Saad graduated from the Faculty of Medicine, Saint Joseph University, Beirut, Lebanon in 2005. He subsequently pursued a residency in Ophthalmology at Hotel Dieu de France, Beirut, then starting 2008 at the Rothschild Foundation in Paris. Dr Saad then completed a fellowship in the cataract, cornea and refractive surgery department lead by Dr Damien Gatinel (2013-2015) at the Rothschild Foundation and he became a full time attending surgeon in this department in June 2015.

Since 2017, Dr Saad is an Assistant Professor of Clinical Ophthalmology at the American University of Beirut, Lebanon and an attending / visiting staff at the Rothschild Foundation in Paris.

Throughout his career, Dr. Saad has maintained a busy clinical practice, and has continued with his teaching activities and research. He is a member of numerous professional societies and a reviewer for several journals in ophthalmology; he has published more than 50 articles in peer- reviewed literature and has given more than 90 oral presentations in local and international meetings. His research interests include new developments in corneal topography and tomography, artificial intelligence application to ophthalmology, wavefront, biomechanics, new intraocular lenses and new keratoplasties technique.

Along with Damien Gatinel, he has developed an artificial intelligence system for the detection of ectasia susceptible eyes: The "SCORE analyzer by Gatinel and Saad" launched in April 2014.

In 2019, he participated to the launching of a new IOL calculation formula based on artificial intelligence called PEARL-DGS (Precision Enhancement using Artificial Intelligence and Output Linearization by Debellemanière, Gatinel and Saad).

Dr Saad is the recipient of the "Achievement Award" from the American Academy of Ophthalmology in 2016 and of multiple best papers / posters awards from the AAO and ASCRS. He was cited and ranked #10 by the journal "The Ophthalmologist" in its power list "top 40 under 40" in 2015 and nominated in the "Rising stars in Ophthalmology" list in 2017.

Presidential Recognition Award

The Presidential Recognition Award is a special award that honors the recipient's dedication and contributions to the field of refractive surgery and to the ISRS.

Presidential Recognition Award—Dr. Robert Edward Ang

Robert Edward Ang MD

Dr. Robert Edward Ang is a senior consultant and head of Cornea and Refractive Surgery Services at the Asian Eye Institute in Makati City, Philippines. He completed his ophthalmology residency training at the Philippine General Hospital and undertook two fellowship training programs (in glaucoma, then cornea and refractive surgery) at the Massachusetts Eye and Ear Infirmary, Harvard Medical School.

In addition to his clinical responsibilities, Dr. Ang's passion includes teaching fellows and residents and performing research studies on presbyopia treatment, IOL technology, and glaucoma devices. Dr. Ang is a clinical investigator for the Supracor presbyopic LASIK algorithm, Kamra corneal inlay, Staar extended depth of focus ICL, AceVision scleral microporation, AcuFocus IC-8 small-aperture IOL, FineVision Trifocal IOL, J&J Symfony EDOF and Synergy IOL, Envista Toric IOL, WIOL polyfocal IOL, Harmoni modular IOL, Bimatoprost SR, Hydrus microstent, and the Glaukos Inject, Supra, and iDose glaucoma devices. Dr. Ang has authored several book chapters and peer-reviewed publications and is an invited speaker at many international conferences. He has received Best Paper awards at the American Society of Cataract and Refractive Surgery (ASCRS), Asia-Pacific Association of Cataract and Refractive Surgeons, and Asia-Pacific Academy of Ophthalmology congresses. In 2013, Dr. Ang received the Certified Educators Award from the Asia Pacific Association of Cataract and Refractive Surgeons. In 2017, Dr. Ang won the Top Gun Instructors Award at the ASCRS conference. In 2018, he was voted as one of the Power List 100 in *The Ophthalmologist* magazine.

Presidential Recognition Award

The Presidential Recognition Award is a special award that honors the recipient's dedication and contributions to the field of refractive surgery and to the ISRS.

Presidential Recognition Award—Dr. J Bradley Randleman

J Bradley Randleman MD

J Bradley Randleman MD is a professor of ophthalmology at the Cole Eye Institute of the Cleveland Clinic Foundation in Cleveland, Ohio. Dr. Randleman received his BA degree from Columbia College at Columbia University in New York City, and his MD degree from Texas Tech University School of Medicine in Lubbock, Texas, where he was elected to the Alpha Omega Alpha medical honor society in his junior year. He then completed ophthalmology residency and a fellowship in cornea, external disease, and refractive surgery at Emory University in Atlanta, Georgia.

Dr. Randleman has been awarded the Claus Dohlman Fellow Award; the inaugural Binkhorst Young Ophthalmologist Award from the American Society of Cataract and Refractive Surgery; the Kritzinger Memorial Award, Founder's Award, and Inaugural Recognition Award from the International Society of Refractive Surgery; and the Secretariat Award, Achievement Award, and Senior Achievement Award from the American Academy of Ophthalmology. He has R01 funding from the NIH to evaluate corneal biomechanical analysis using Brillouin microscopy.

Dr. Randleman has served as editor-in-chief for the *Journal of Refractive Surgery* since 2011. He has authored more than 150 peer-reviewed publications in leading ophthalmology journals, in addition to 40 book chapters on refractive surgery evaluation, corneal crosslinking, and management of complications with IOLs, and has authored four textbooks, *Collagen Cross-Linking* and *Corneal Cross-Linking*, 2nd edition, which he co-edited on Farhad Hafezi MD PhD, *Refractive Surgery: An Interactive Case-Based Approach*, and *Intraocular Lens Surgery: Selection, Complications, and Complex Cases.*

28th Annual Richard C Troutman MD DSc (Hon) Prize

The Troutman Prize recognizes the scientific merit of a young author publishing in the *Journal of Refractive Surgery*. This prize honors Richard C Troutman MD DSc (Hon).

Richard C Troutman MD DSc (Hon) Prize—Dr. Carla Santos Medeiros

Carla Santos Medeiros MD PhD

Dr. Carla Medeiros is a medical doctor, PhD, and science enthusiast. She obtained her medical degree and completed her ophthalmology residency and corneal surgery fellowship in Brazil.

Her scientific journey began with a doctoral program at the University of São Paulo, Brazil, under Dr. Marcony Santhiago's supervision, followed by a post-doctoral fellowship at Cleveland Clinic Foundation in the United States.

As Dr. Steven Wilson's fellow, Dr. Medeiros applied her skills as a refractive and cornea surgeon in laboratory experiments using animal models, aiming for a better comprehension of corneal wound-healing mechanisms focused on predicting better outcomes. Her clinical and research work are centered in corneal crosslinking and wound-healing response after corneal refractive surgery, infections, and injury.

Dr. Medeiros has published 14 original scientific articles in peer-reviewed journals, seven book chapters, and 30 lectures in national and international meetings. Back in Brazil, she currently works as a corneal and refractive surgeon specialist. She is passionate about teaching, and as head of the refractive surgery department at a philanthropic hospital, she helps ophthalmology residents to improve their skills.

Faculty

Amar Agarwal MD
Chennai, India

Gerd U Auffarth MD
Heidelberg, Germany

John So-Min Chang MD
Hong Kong, Hong Kong

Ashvin Agarwal MD
Chennai, India

George Beiko MD
St Catharines, Canada

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Miami, FL

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George O Waring IV MD
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Refractive Surgery Subspecialty Day 2019: As Far as the Eye Can See

The Annual Meeting of the International Society of Refractive Surgery

Sponsored by ISRS

FRIDAY, OCT. 11, 2019

7:00 AM	CONTINENTAL BREAKFAST		
8:00 AM	Opening Remarks	Marcony R Santhiago, MD* George O Waring IV MD*	

Keynote Lecture

8:05 AM	IOL Calculations: Can We Do Better?	Douglas D Koch MD*	1

Section I: The Current State of Intraocular Refractive Surgery

Moderators: Burkhard Dick MD* and William B Trattler MD*

Panelists: Ashvin Agarwal MD, George Beiko MD*, Sheraz M Daya MD*, Aylin Kilic MD, and Julian D Stevens DO*

8:15 AM	Synthesizing Data to Optimize Astigmatism Correction in Lens Surgery	Noel A Alpins MD FACS*	2
8:21 AM	Innovations in Postoperative IOL Adjustment	Burkhard Dick MD*	4
8:27 AM	Presbyopic IOL Overview: Current and Future Innovations	Gerd U Auffarth MD*	5
8:33 AM	Prevention and Management of Positive and Negative Dysphotopsias	Jack T Holladay MD MSEE FACS*	6
8:39 AM	Optimizing Pharmaceutical Agents for Refractive Lens Surgery	William B Trattler MD*	9
8:45 AM	Advances in Presbyopic IOLs: Expanding Eligibility in Previous Borderline Cases	Arthur B Cummings MD*	10
8:51 AM	Managing Refractive IOLs in the Setting of a Compromised Posterior Capsule	Karolinne M Rocha MD*	11
8:57 AM	Modulating the Cornea in Patients Who Are Off Target With Refractive IOLs	Scott M MacRae MD*	13
9:03 AM	Discussion		

Section II: Corneal Laser Vision Correction—Beyond the Usual Knowledge

Moderators: Daniel S Durrie MD* and George O Waring IV MD*

Virtual Moderator: Glauco H Reggiani Mello MD

Panelists: Damien Gatinel MD*, Soosan Jacob MBBS FRCS*, Marguerite B McDonald MD*, Roberto Pineda II MD*, and Vance Michael Thompson MD*

9:13 AM	Descemet Membrane Role in Modulating Corneal Wound Healing	Steven E Wilson MD*	14
9:19 AM	Managing LASIK Complications	Sonia H Yoo MD*	15
9:25 AM	Managing SMILE Complications	Dan Z Reinstein MD*	16
9:31 AM	Topography-Guided Treatments	A John Kanellopoulos MD*	18
9:37 AM	Medical Treatment of Presbyopia	Sheri Rowen MD*	22

* Indicates that the presenter has financial interest. No asterisk indicates that the presenter has no financial interest.

9:43 AM	Future Directions of Corneal-Based Laser Vision Correction	Ronald R Krueger MD*	24
9:49 AM	Discussion		
10:05 AM	REFRESHMENT BREAK		

ISRS Awards

10:35 AM	Presentation of ISRS Awards	John So-Min Chang MD*	

Keynote Lecture II

10:45 AM	Identifying the Pre-ectatic Cornea: Big Steps, Missteps, and Next Steps	J Bradley Randleman MD	25

Section III: It's Time for an Update in Refractive Surgery

Moderators: Stephen D McLeod MD and Marcony R Santhiago MD*

Panelists: Maria Jose Cosentino MD, Luis Izquierdo Jr MD, Jodhbir S Mehta MBBS PhD, Claudia E Perez-Straziota MD, and Cynthia Roberts PhD*

11:00 AM	Understanding Percent Tissue Altered as a Risk Factor for Ectasia After Excimer Laser Surgery	Marcony R Santhiago MD*	26
11:09 AM	Analysis of Corneal Structural Response and Ectasia Risk in Myopic Laser Refractive Surgery	William J Dupps MD PhD*	29
11:18 AM	Subclinical Keratoconus Detection by Pattern Analysis of Epithelial Maps With OCT	David Huang MD PhD*	30
11:27 AM	Influence of Corneal Posterior Astigmatism in Normal Eyes and Keratoconus	Wallace Chamon MD*	31
11:36 AM	Integration of Scheimpflug-Based Tomography and Biomechanical Assessments	Paolo Vinciguerra MD*	32
11:45 AM	Advances in Corneal Topography	Stephen D Klyce PhD*	33
11:54 AM	Update in Corneal Crosslinking: Where Are We Now?	Theo Seiler MD PhD	34
12:03 PM	Update on Emerging Accommodating IOLs in Early Development	Stephen D McLeod MD	35
12:12 PM	Discussion		
12:22 PM	LUNCH, South, Room 151 ISRS Member Lunch, SMILE, South, Room 152 (ticket required)		

Section IV: Video-Based Master Complications

Moderators: Amar Agarwal MD* and William J Fishkind MD FACS*

Panelists: Deepinder K Dhaliwal MD*, Terry Kim MD*, Jennifer M Loh MD*, and John Allan Vukich MD*

1:47 PM	Residual Astigmatism After Toric IOL Implantation	George O Waring IV MD*	36
1:52 PM	IOL Scaffold	Yuri McKee MD*	37
1:57 PM	Glued IOL: Yamane Techniques	Eric D Donnenfeld MD*	38
2:02 PM	Pinhole Pupilloplasty	Amar Agarwal MD*	39
2:07 PM	Posterior Capsular Rupture in a Toric IOL Patient	David F Chang MD*	42
2:12 PM	Femto Laser Without Suction	John So-Min Chang MD*	43
2:17 PM	LASIK Nightmares	Samir A Melki MD PhD*	44
2:22 PM	SMILE to Frown	Renato Ambrósio Jr MD*	45
2:27 PM	Discussion		

* Indicates that the presenter has financial interest. No asterisk indicates that the presenter has no financial interest.

Section V: The *Journal of Refractive Surgery*'s Hot, Hotter, Hottest: Late Breaking News

Moderator: J Bradley Randleman MD

2:37 PM	Introduction of Troutman Prize	J Bradley Randleman MD	
2:42 PM	The Impact of Photorefractive Keratectomy and Mitomycin C on Corneal Nerves and Their Regeneration	Carla S Medeiros MD	49
2:57 PM	Influence of Microstructure on Stiffening Effects of Corneal Crosslinking Treatment	Hamed Hatami-Marbini PhD	50
3:03 PM	Oxygen Diffusion May Limit the Biomechanical Effectiveness of Iontophoresis-Assisted Transepithelial Corneal Crosslinking	Emilio A Torres-Netto MD*	51
3:07 PM	Bilaterally Asymmetric Corneal Ectasia Following SMILE With Asymmetrically Reduced Stromal Molecular Markers	Rohit Shetty MD FRCS PhD*	52
3:12 PM	Biomechanics of LASIK Flap and SMILE Cap: A Prospective, Clinical Study	Pooja Khamar MBBS MS	53
3:17 PM	CIRCLE Enhancement After Myopic SMILE	Jakob Siedlecki MD*	54
3:22 PM	A Comparative Evaluation of a New Generation of Diffractive Trifocal and Extended Depth of Focus IOLs	Beatrice Cochener MD PhD*	56
3:27 PM	Dissatisfaction After Trifocal IOL Implantation and Its Improvement by Selective Wavefront-Guided LASIK	Theo G Seiler MD*	57
3:32 PM	Primary Topography-Guided LASIK: Treating Manifest Refractive Astigmatism vs. Topography-Measured Anterior Corneal Astigmatism	Avi Wallerstein MD FRCSC	58
3:37 PM	Discussion		
3:52 PM	*JRS* QwikFacts	Marcony R Santhiago MD*	
3:57 PM	Are You AT the Table or ON the Menu?	Stephanie Jones Marioneaux MD	59
4:02 PM	REFRESHMENT BREAK		

Section VI: ESCRS Symposium: What Happened to Our Patient in the Long Term?

Moderator: Beatrice Cochener MD*

4:32 PM	After Substractive Corneal Surgeries	Thomas Kohnen MDPhD FEBO*	61
4:40 PM	After Phakic IOLs	Rudy Nuijts MD*	61
4:48 PM	After Toric Implantation	Oliver Findl MD	61
4:56 PM	After Multifocal IOLs	Beatrice Cochener MD*	61
5:04 PM	Discussion		
5:17 PM	Closing Remarks	Marcony R Santhiago MD* George O Waring IV MD*	
5:19 PM	Adjourn		

* Indicates that the presenter has financial interest. No asterisk indicates that the presenter has no financial interest.

IOL Calculations: Can We Do Better?

Douglas D Koch MD

I. The accuracy of IOL calculations has increased dramatically, thanks to better hardware and software. However, in many practices, fewer than 80% of eyes achieve outcomes within 0.5 D of target, and the best results just break 90%—which means that 1 in 10 eyes are off by more than 0.5 D.

II. It's time to reclassify our formulas based on their function: how they calculate IOL and not based on "generations."

   A. Vergence: describe by the number of variables used to calculate effective lens position (ELP)

      1. Two-variable vergence: Holladay 1, SRK-T, HofferQ

      2. Three-variable vergence: Haigis

      3. Five-variable vergence: Barrett Universal II

      4. Seven-variable vergence: Holladay Consultant

   B. Ray tracing

      1. PhacoOptics (Thomas Olsen)

      2. Okulix (Rolf Preussner)

   C. Artificial intelligence

      1. Hill RBF

      2. Gerald Clarke

   D. Combination

      1. Ladas Super Formula

      2. Full Monte IOL

III. Fundamentally, all formulas try to estimate the postoperative ELP.

   A. Which is better? In most studies, the Barrett U2, Hill RBF, Olsen, and Holladay Consultant are reported to provide best outcomes.

   B. What are the sources of error?

      1. In his classic 2008 paper, Norrby stated that the major sources of error were ELP, axial length, and refraction.

      2. Today, thanks to optical biometry, axial length is no longer among the top 3, with corneal measurements now on this list, in addition to ELP and refraction. That said, measuring the axial length in segments rather than as a whole could increase the accuracy in very short and very long eyes.

IV. Challenging Situations

   A. Long eyes: The problem of unanticipated hyperopic outcomes in long eyes has largely been eliminated with the Wang-Koch axial length modification and the Barrett, Hill RBF, and ray tracing formulas.

   B. Short eyes: For eyes less than 22 mm, accuracy remains below 80% within 0.5 D of target because of the impact that small shifts in the ELP of high-power IOLs have on the refractive outcome.

   C. Post–refractive surgery: Results for these eyes are more disappointing, with most studies showing accuracy below 70% within 0.5 D of target.

   D. Keratoconus: Hyperopic surprises are common, and the steeper the cornea, the greater the hyperopic outcome.

V. Future Considerations

   A. Several efforts are being made to improve the accuracy of predicting ELP, but none have demonstrated improved outcomes.

   B. Postoperative modification of IOL power is promising, with 2 technologies currently available or under investigation:

      1. RxSight: curvature change via selective laser-induced molecular polymerization

      2. Refractive index shaping: can theoretically be done in vivo to an IOL—and in the cornea

Selected Readings

1. Koch DD, Hill W, Abulafia A, Wang L. Pursuing perfection in intraocular lens calculations: I. Logical approach for classifying IOL calculation formulas. *J Cataract Refract Surg.* 2017; 43(6):717-718.

2. Melles RB, Holladay JT, Chang WF. Accuracy of intraocular lens calculation formulas. *Ophthalmology* 2018; 125:169-178.

3. Norrby S. Sources of error in intraocular lens power calculation. *J Cataract Refract Surg.* 2008; 34:368-376.

4. Wang L, Cao DM, Weikert MP, Koch DD. Calculation of axial length using a single group refractive index versus using different refractive indices for each ocular segment: theoretical study and refractive outcomes. *Ophthalmology* 2019; 126:663-670.

5. Gökce SE, Zeiter JH, Weikert MP, Koch DD, Wang L. IOL power calculations in short eyes using seven formulas. *J Cataract Refract Surg.* 2017; 43(7):892-897.

6. Wang L, Tang M, Huang D, Weikert MP, Koch DD. Comparison of newer IOL power calculation methods for post-corneal refractive surgery eyes. *Ophthalmology* 2015; 122(12):2443-2449.

7. Brierley L. Refractive results after implantation of a light-adjustable intraocular lens in postrefractive surgery cataract patients. *Ophthalmology* 2013; 120:1968-1972.

Synthesizing Data to Optimize Astigmatism Correction in Lens Surgery

Noel Alpins MD FACS

The key aspect to optimizing astigmatism outcomes after lens surgery is in understanding exactly how accurate the toric IOL calculator you use for planning the surgery is.

Does the toric IOL calculator do the following:

1. Calculate the spherical as well as the toric power of the IOL

The formulae required to calculate the spherical component use the anterior corneal power and not the total corneal power. Using the corneal refractive index stipulated by the device used to measure the corneal power will add accuracy. The toric power is calculated using the anterior corneal power measurements or the adjusted anterior corneal power measurements for the effect of the posterior cornea, providing an estimated total corneal power or, more accurately, a measured total corneal power.

2. Use the axial length to determine the toricity of the IOL

This is important when determining the effective lens position of the IOL and hence the spherical and toric power. Eyes with an axial length of more than 25.00 mm should be adjusted using the Wang/Koch recommendation, otherwise undesired hyperopia will result.

3. Use total corneal power

Using measured total corneal power instead of estimations is more accurate, as there is a widespread contribution of posterior corneal astigmatism to the total corneal astigmatism, particularly for oblique and against-the-rule astigmatism. Be sure to check if the toric calculator you are using is not already factoring in an adjustment for the posterior cornea, so by entering total corneal power you are doubling up on the contribution of the posterior cornea. The corneal topographic astigmatism (CorT) total parameter is a very accurate measure of corneal astigmatism that measures the combined effect of both anterior and posterior cornea.

4. Allow for the flattening effect (FE) of the phaco incision

This is determined from analyses of previous surgeries and is the effect at the site of the incision. This will affect the magnitude and the meridian of the corneal astigmatism and hence the toric power and axis of the IOL. Note that this is not the surgically induced astigmatism vector (SIA), as this overstates the effect of the incision because it includes the torque component when the SIA is not orthogonal with the incision as well as the flattening of the incision. The mean systematic FE should not be considered to be zero unless postoperative analyses have determined this.

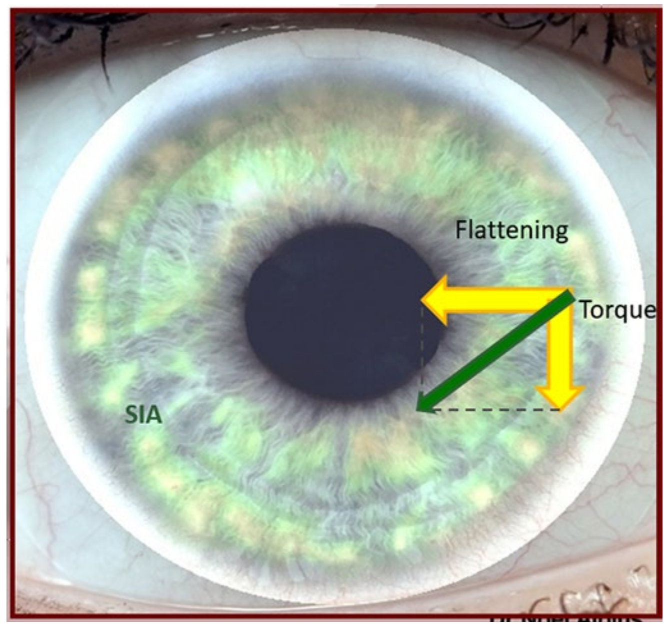

Figure 1. The surgically induced astigmatism vector (SIA) is composed of the flattening/steepening effect and the torque.

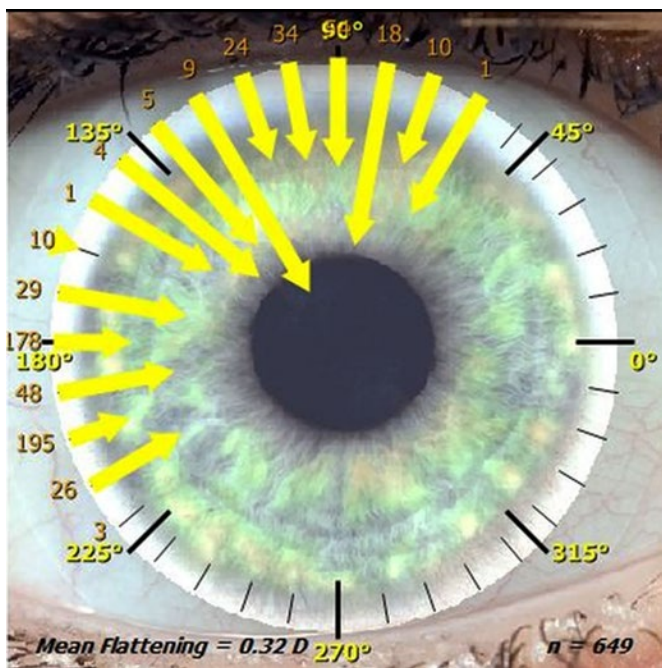

Figure 2. The flattening effect of phacoemulsification incision in the right eye. The numbers around the limbus are the number of cases at that meridian. The longer the yellow arrow pointing toward the pupil, the greater the flattening effect.

5. Have the latest toric IOL parameter range from the manufacturer

The toric IOL ranges available from the various manufacturers can vary. It is important that the calculator have the latest IOL power parameters, including dioptric toric step availability as well as spherical, if this is also being determined by the calculator.

6. Allow for personalized IOL constants for the individual surgeon

This should include not only the SRK/T A-constant but also the Hoffer Q, Holladay, Haigis, and other formulas to accurately calculate the effective lens position and the power of the toric IOL.

7. Factor in the spherical component of IOL when converting the power of the toric component from the IOL plane to the corneal plane

8. Have the ability to analyze and calculate any rotation of the toric IOL required to reduce post-refractive cylinder surprise

The new axis may not necessarily coincide with the steep postoperative corneal meridian.

Understanding exactly what is and is not included in your toric IOL calculator will enable improved astigmatic outcomes. IOL formulae need to coexist in calculators with the above features to optimize visual results.

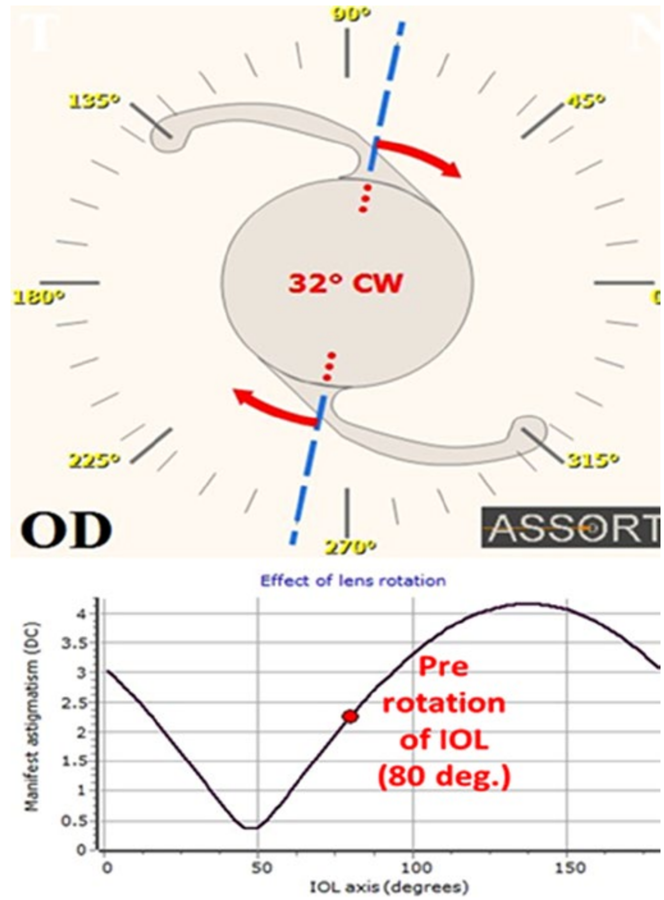

Figure 3. In this example, rotation of the toric IOL 32 degrees clockwise will reduce the postoperative refractive cylinder from 2.25 D to less than 0.50 D.

Innovations in Postoperative IOL Adjustment

H Burkhard Dick MD

It is common knowledge: Cataract surgery these days is always refractive surgery. Patients are more demanding than ever, and sometimes even 20/20 vision is not good enough if even minor additional correcting glasses are required to achieve that visual acuity. A large European study has demonstrated that refractive outcomes after cataract surgery indeed leave something to be desired: of more than 280,000 interventions, 93% were within ±1.0 D and 72.7% within ±0.5 D of target refraction, which means 27% of eyes had a postoperative refractive error of half a diopter or more.[1] Refractive error is one of the major causes for IOL explantations. The numbers may likely further increase since the first generation of corneal refractive patients is now reaching cataract age and IOL power calculation tends to be more difficult in these eyes, with an increased likelihood of refractive error after cataract surgery.

Different technologies to adjust IOL power have been developed. The light-adjustable lens (LAL) has been part of our clinical routine for more than 10 years now; the vast amount of experience underscores the value of this 3-piece silicone lens, whose refractive power can within in few weeks after cataract surgery be changed by specifically targeted UV irradiation. The LAL (RxSight, Inc.; Aliso Viejo, California, USA) gained FDA approval in November 2017. Spherical power can be adjusted by about 2 D (plus or minus), cylindrical power can be altered in a range from 0.25 to about 2 D.[2] The enhancement, which can also correct individual asphericity, is easy to perform and has a good safety record, without any influence (eg, on the incidence of postoperative macular edema).[3]

A promising technology currently under development is refractive index shaping by femtosecond laser, also known as LIRIC (laser-induced refractive index change). This method uses low pulse energies below the ablation threshhold to modify the refractive index of the cornea or of an implanted IOL (and also of a contact lens). When performed on the cornea, there is no damage to the corneal nerves and thus there is much less dry eye than post-LASIK. Scott McRae, one of the pioneers of this technique, has called it “potentially the perfect method for fine-tuning the results of IOL implantation in case of residual refractive error.” The technology may even go beyond correcting residual refractive errors, including astigmatism. The laser modification, done with an ultra-small spot size of about 0.5 µm (compared to ca. 500 µm in LASIK), is able to turn a monofocal IOL into a multifocal lens—and vice versa; for a patient who turns out not being able to cope with the pecularities of vision under multifocality, “reducing” the implanted multifocal IOL to a monofocal IOL might be a much less invasive option that another surgery for IOL replacement. Research is going on to develop IOL material particularly suitable for postoperative refractive index shaping.

Infinite Vision Optics, a French manufacturer, has introduced an new concept of a lens system that consists of two elements that are preassembled prior to surgery. In cases of refractive error, the IOL’s power can be altered by a small intervention: the upper optic, called the front lens, will be exchanged by minimally invasive surgery and replaced by an new component that better serves the patient’s vision. Thus a total IOL explantation does not become necessary. The multicomponent lens (PreciSight) was implanted in Europe for the first time in July 2018. This year, a first report on about 25 eyes that underwent postoperative refractive enhancement about 3 months after primary surgery was published. These eyes gained on average 2 lines of uncorrected distance visual acuity and had a significant decrease in residual spherical equivalent, from 1.3 ±1.1 D to 0 ±0.38 D ($P < .001$). While all enhancement surgery was uneventful and no major complications were reported, there was a certain loss of endothelial cell density (about 2.6%), which was considered to be a result of primary cataract surgery.[4]

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1. Lundström M, Dickman M, Henry Y, et al.Risk factors for refractive error after cataract surgery: analysis of 282 811 cataract extractions reported to the European Registry of Quality Outcomes for cataract and refractive surgery. *J Cataract Refract Surg.* 2018; 44(4):447-452.
2. Moshirfar M, Wagner WD, Linn SH, et al.Astigmatic correction with implantation of a light adjustable vs monofocal lens: a single site analysis of a randomized controlled trial. *Int J Ophthalmol.* 2019; 12(7):1101-1107.
3. Hengerer FH, Müller M, Dick HB, Conrad-Hengerer I. Clinical evaluation of macular thickness changes in cataract surgery using a light-adjustable intraocular lens. *J Refract Surg.* 2016; 32(4):250-254.
4. Uy HS, Tesone-Coelho C, Ginis H. Enhancement-procedure outcomes in patients implanted with the Precisight multicomponent intraocular lens.*Clin Ophthalmol.* 2019; 13:107-114.

Presbyopic IOL Overview: Current and Future Innovations

Gerd U Auffarth MD

NOTES

Prevention and Management of Positive and Negative Dysphotopsias

Jack T Holladay MD MSEE FACS

General Terms for Categorizing Patient Symptoms Following Cataract Surgery or Refractive Surgery

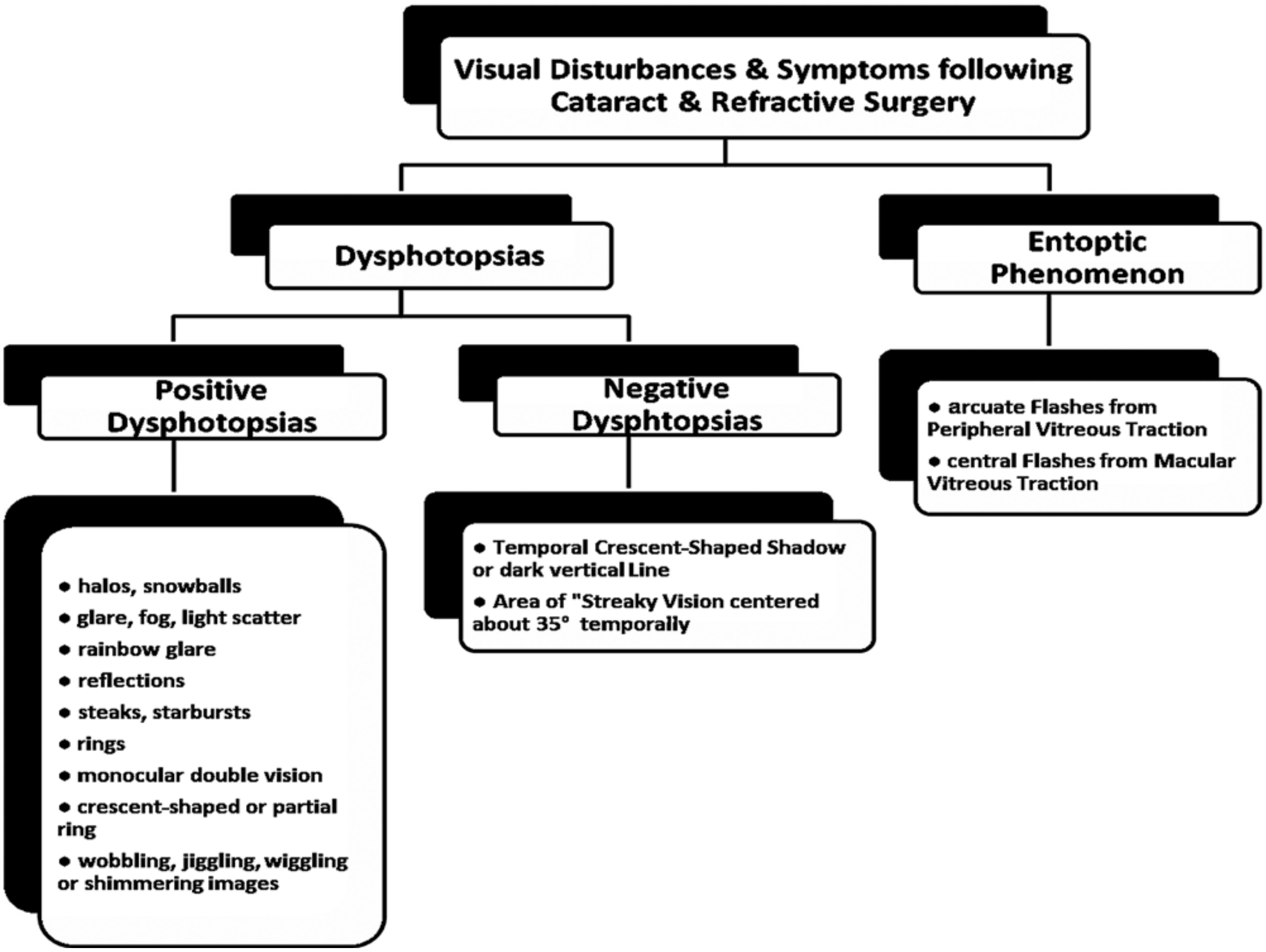

Figure 1. Visual disturbances and symptoms following cataract or refractive surgery.

Entoptic Phenomenon

From the Greek ἐντός, "within," and ὀπτικός, "visual," entoptic phenomenon are visual effects whose source is within the eye itself. They are most commonly seen as peripheral or central light flashes (occasionally referred to by the patient as flickering) and are usually a result of partial peripheral or central vitreous collapse that causes traction on the retina, resulting in the perception of light without any light stimulus. The flashes occur with the eye closed in complete darkness when the head or eye is moved quickly from side to side (or up and down). It has nothing to do with the IOL except that it frequently occurs immediately after cataract surgery because the IOL occupies a much smaller volume than the crystalline lens, resulting in a larger posterior compartment for the same original volume for the vitreous body.

Treatment

Refer to Retina.

Dysphotopsias

A general term that indicates unwanted *optical* phenomenon seen by the patient. It does not include entoptic phenomenon.

Negative dysphotopsia

A dark, temporal crescent that gives the impression of a shade over the temporal region of patients' vision, normally seen in photopic or high mesopic conditions. It is exaggerated by pupil constriction and reduced by dilation. Examples of patient drawings are shown in Figure 2.

Treatment

1. Remove nasal overlapping capsule.
2. Reverse optic capture, or
3. Exchange with silicone IOL. Rounded edge optics are no longer available in the USA.

Positive dysphotopsias

Unwanted optical images including halos, glare, fog, light scatter, reflections, steaks, starbursts, rings, monocular double vision, crescents and wobbling, jiggling, wiggling, or shimmering images.

Causes

- **Cause from poor patient optics** when Chord Mu > 0.6 mm or HOA RMS WE > 1.0 µm. Do not use diffractive multifocal IOL.
- **Cause from IOL optics**
  - Diffractive optics: Glare in the form of "snowballs," "halos," "streaks," or "starburst," as shown in Figure 3. The only treatment is exchange for monofocal IOL.
  - Truncated edge (square): IOL edge reflection (see Figure 4); nighttime (Figure 5) and daytime (Figure 6) arcuate flashes..

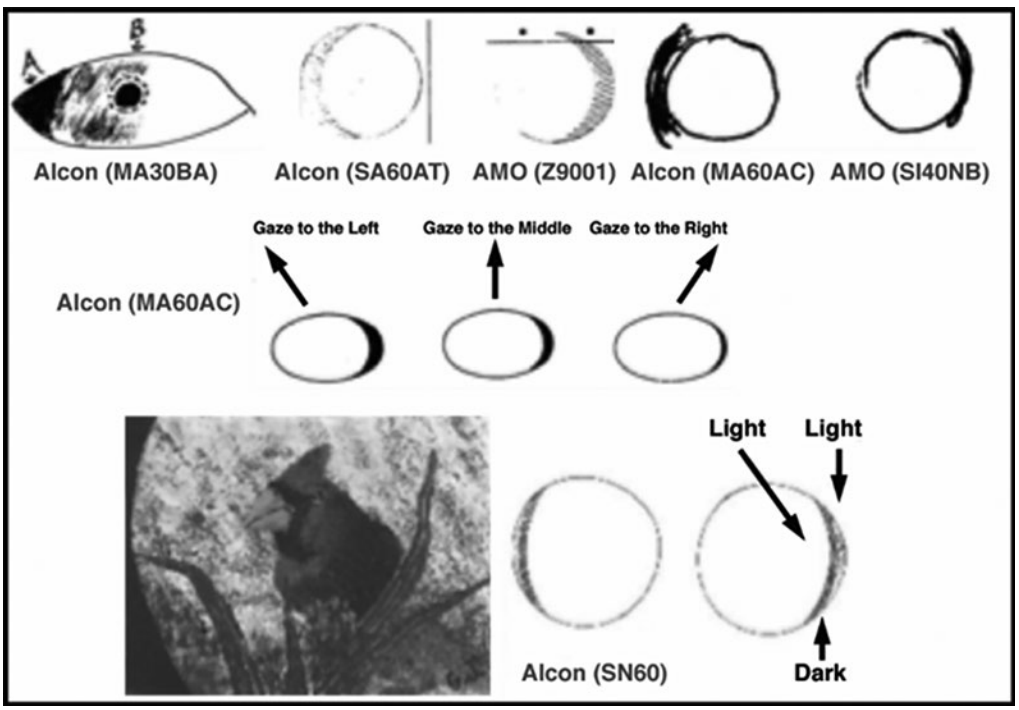

Figure 2. Patient drawings of negative dysphotopsia.

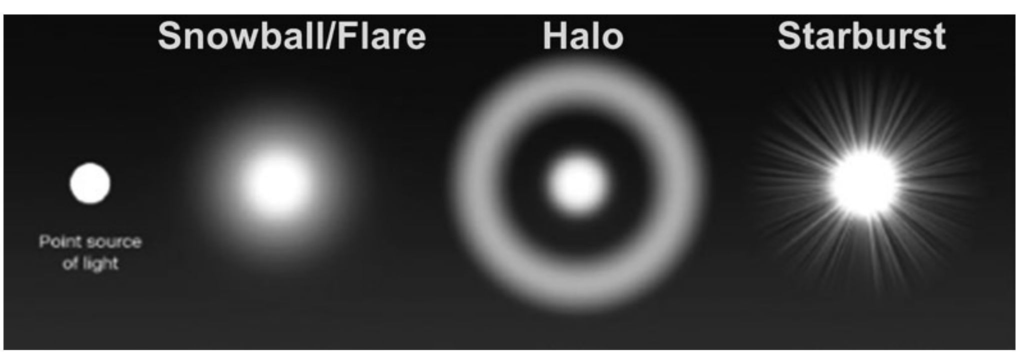

Figure 3. Glare: snowball, halo, streak and starburst.

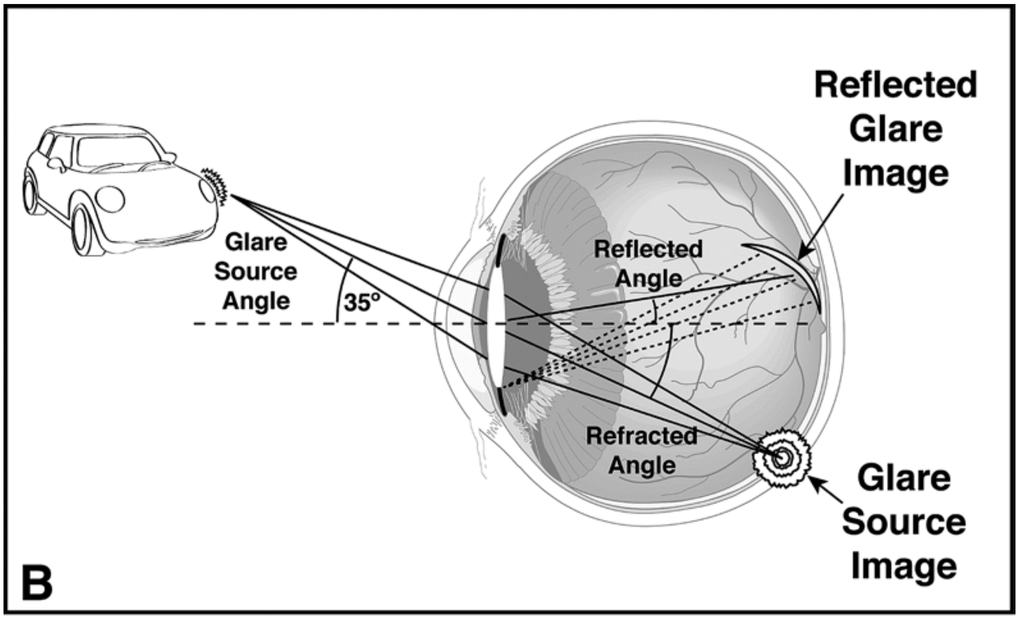

Figure 4. IOL edge reflection.

Figure 5. Nighttime arcuate flashes.

Figure 6. Daytime arcuate flashes.

Treatment

Rounded edge optics are no longer available in the USA, so exchanging for silicone IOL is the only choice.

Pseudophakodonesis (unstable fixation of IOL)

Give a few weeks to stabilize … If IOL → exchange IOL. If capsule → capsular tension ring (CTR).

Selected Readings

1. Holladay JT, Simpson MJ. Negative dysphotopsia: causes and rationale for prevention and treatment. *J Cataract Refract Surg.* 2017; 43:263-275.
2. Masket S, Rorer E, Stark W, et al. Special report: the American Academy of Ophthalmology Task Force consensus statement on adverse events with intraocular lenses. *Ophthalmology* 2017; 124:(1):142-144.
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Optimizing Pharmaceutical Agents for Refractive Lens Surgery

William Trattler MD

I. Pharmaceutical agents used with refractive lens surgery are focused around two main areas:

A. Prevention of infection

B. Prevention and treatment of inflammation

II. Over the past two decades, clinical trials and studies have determined the following:

A. Intraocular antibiotics can significantly reduce the risk for infection with lens surgery. The two main classes are:

1. Fluoroquinolones: Moxifloxacin

2. Cephalosporins

B. Vancomycin has been largely abandoned due to the rare but serious risk for hemorrhagic occlusive retinal vasculitis (HORV).

C. There are currently no antibiotics that are FDA approved for prevention of infection.

D. While topical antibiotics started 1 to 3 days ahead of time may potentially reduce the levels of bacteria in and around the ocular surface, there are no controlled studies that have definitely proven that topical antibiotics lower the risk for infection.

III. Inflammation if unchecked, can lead to cystoid macular edema (CME), corneal swelling, and other findings.

A. Most centers in the United States use a combination of a topical NSAID and topical steroid, as the combo appears to lower the risk for CME.

B. Some surgeons use only steroids for inflammation control. Other surgeons use only NSAIDs for inflammation control.

C. Phenylephrine and kerorolac intraocular solution (Omidria) was approved in 2016 and is effective at keeping the pupil large during surgery, as well as reducing pain postoperatively.

D. Dexamethasone intraocular suspension 9% (Dexycu) was approved in 2018. It is a small pellet of sustained-release dexamethasone that is placed behind the iris at the conclusion of the procedure. It is effective for lowering intraocular inflammation.

E. Dexamethasone ophthalmic insert (Dextenza) was approved in 2019. It is placed in the lower punctal system and provides sustained release of dexamethasone for 30 days.

F. Some surgeons place intracameral or intravitreal dexamethasone that is created at a compounding pharmacy.

III. Summary

There are exciting options for perioperative medications in and around refractive cataract surgery.

Advances in Presbyopic IOLs: Expanding Eligibility in Previous Borderline Cases

Arthur Cummings MD

Introduction

Patients undergoing IOL surgery, whether for cataract extraction or refractive lens exchange to achieve less dependence on spectacles, are opting for multifocal or presbyopia-correcting IOLs more so than in the past. Although the growth of this is relatively slow, the trend is upward.

Background Observations

Given modern lifestyles, with computer usage at all-time highs and the use of smartphones and tablets for work and entertainment, patients are seeking solutions for near and intermediate vision, too. In our own experience, patients who have had previous vision correction are more likely to consult us for near vision solutions than those who have not had previous surgery. This is very likely due to self-selection, with the previous-vision-correction group simply displaying the fact once more that they do not like spectacles, albeit reading spectacles this time.

Previous corneal surgeries may have led to an increase in corneal higher-order aberrations (HOAs), however, with small optical zones, decentered optical zones, or a combination of the two. From experience, we all know that presbyopia-correcting IOLs work best in the presence of good corneal optics (ie, low HOAs and small angle kappa/angle alpha).

If the corneal HOAs are above 0.4 microns hRMS, then the likelihood of delivering a highly satisfactory result is diminished. If the angle kappa is larger than 450 microns (0.45 mm), there is also an increased risk of glare and haloes with refractive and diffractive multifocal IOLs.

In these previously treated cases, the management is more complicated and the following options exist:

1. Stay away from multifocal IOLs.
2. Think about monovision or blended vision instead.
3. In Europe and OUS, colleagues are achieving excellent results with pinhole optics IOLs.
4. First regularize the cornea with a topography-guided laser vision correction to recenter or enlarge the optical zone. Then, once the HOAs are sufficiently low, opt for IOL surgery.
5. The sequence can also be reversed: Do the IOL surgery first and then do the topography-guided laser vision correction (TG-LVC).

Pro/Con Debates

The two latter approaches have their pros and cons. Neither TG-LVC (for aberrated corneas) nor IOL power calculations using optical biometry are as predictable as regular wavefront-optimized LVC or IOL predictability in non-previously operated eyes. So, regardless of whether the LVC is performed first or second, there is an increased chance of requiring a top-up LVC enhancement to nail the refractive component. If the IOL is performed first and then followed by the TG-LVC, there is a chance of requiring a touch-up LVC for the residual refractive error. If the TG-LVC is performed first and then the IOL is done, there is still a chance of requiring LVC to address the residual refractive error. In fact, it is slightly higher with option 2, as now this is a result of the effective lens position (ELP) and the relative refractive unpredictability of the TG-LVC. Whatever pathway is selected, the patient needs to be made aware that they are going to require 3 treatments, possibly. If the final result is achieved after 2 procedures only, then they are even happier with the outcome.

My sense is to do the TG-LVC first for 2 reasons: often this improves the vision enough that the patient postpones the IOL surgery for another day when the lens is becoming more cataractous, and secondly, the IOL calculations tend to be a bit more predictable with lower standard deviation when the cornea is regular.

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Managing Refractive IOLs in the Setting of a Compromised Posterior Capsule

Karolinne Maia Rocha MD, Molly Orban MD, Larissa Gouvea MD, and Vinicius De Stefano MD PhD

I. Posterior Capsule Rupture: Signs

   A. Deepening of the anterior chamber

   B. Miosis

   C. Surge

   D. Lens stops moving the same

   E. Corectopia

   F. Increased post pressure

II. IOLs in the Setting of a Compromised Posterior Capsule: Algorithm

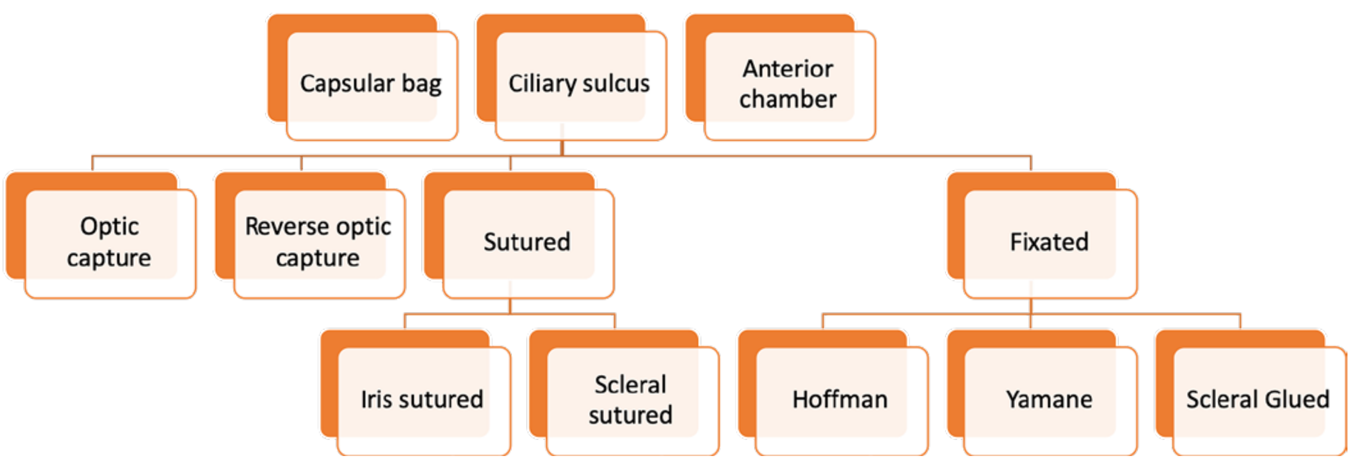

Figure 1.

III. In the Bag

   A. Round posterior capsule tear: If there is a small linear tear, you can make a *small* (2-3 mm) posterior capsulorrhexis and place the IOL in the bag.

   B. Good zonular support

   C. Can use 1-piece IOL

IV. In the Sulcus

   A. If irregular or large posterior/anterior tear + good zonular support

      1. Optic capture

         a. IOL optic in the bag

         b. Haptics in the sulcus

         c. 3-piece IOL (PC-IOL options)

      2. Reverse optic capture

         a. IOL optic in the sulcus

         b. Haptics in the bag

         c. 3-piece IOL

         d. Or 1-piece IOL (toric, PC-IOL, PC-IOL/toric)

   B. Irregular or large tear + poor zonular support

   C. Must fixate the lens outside of the capsular bag—"extracapsular fixation"

D. Sutured IOL
   1. Iris sutured
      a. Gor-Tex suture (off label)
      b. Polypropylene
   2. Scleral sutured
      a. Gor-Tex suture (off label)
      b. Polypropylene (belt-loop technique using 5.0 polypropylene)

E. Downsides
   1. Need enough iris tissue
   2. Corectopia (suture peripherally)
   3. Pigment dispersion

F. Upsides
   1. Doesn't disturb conjunctiva
   2. Small incision
   3. Lower risk of endophthalmitis (no external suture/haptic)

G. Irregular/large tear + poor zonular support

V. Yamane Technique

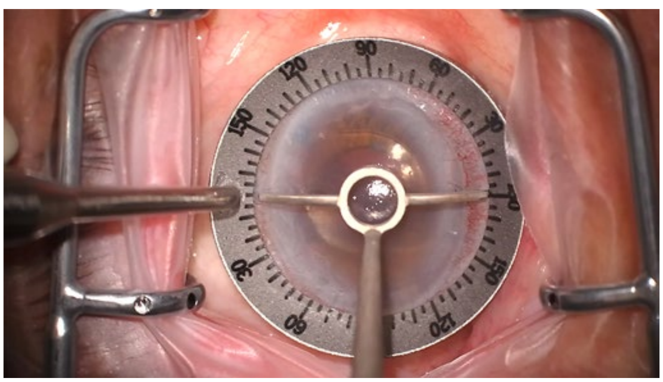

Figure 2.

VI. Hoffman Technique

IOL choice: 3-piece IOL, or single-piece PMMA (CZ70BD). See "IOL suturing, scleral fixation of foldable IOL, Hoffman technique" at youtube.com/watch?v=F1q0s3Hy4do#action=share.

VII. Anterior Chamber
   A. If there is no zonular support and no capsular bag
   B. Least desirable option
   C. Endothelial loss

VIII. Power Selection
   A. In the bag: Same power
   B. In the sulcus: 0.5 D less power
   C. In the anterior chamber: AC-IOL calculation

IX. Back to Posterior Capsule Rupture: Complications
   A. Vitreous prolapse: infection, leakage
   B. Retinal detachment: Vitreous prolapse puts traction on the retina.
   C. Cystoid macular edema
   D. Damage to the iris, hyphema

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Modulating the Cornea in Patients Who Are Off Target With Refractive IOLS

Scott MacRae MD

I. Correct Sphere and Astigmatism
   A. "At 1-3 months, 57.6% of premium IOL eyes may not have received full benefit due to refractive error." R Lindstrom, 2012
   B. Multifocals, enhanced depth of focus (EDOFs) disproportionately affected by refractive error

II. Optics, Optics, Optics
   A. Understand the patient's optics, preop, and address them aggressively pre- and intraoperatively to prevent postop residual astigmatism, sphere, and irregular astigmatism.
      1. Evaluate corneal topography to Optimize Corrections: Rule out irregular astigmatism preoop.
      2. Postop manifest refraction; repeat it if *any* uncertainty.
   B. Multifocals, diffractive, and EDOF IOLs are more sensitive to refractive error, especially astigmatism. 0.75 D of astigmatism can cause reduction in visual quality and performance even with monofocals, but more with multifocals.

III. Multifocal IOLs (M-IOLs)
   A. Correct sphere to within 0.25-0.30 D of emmetropia
   B. ReStor 3 and 4, Tecnis multifocals, EDOF
   C. Astigmatism up to <0.75 D tolerated, but there are exceptions.
   D. Early postop: Adjust toric IOL (Berdahl-Harden Astigmatism Fix Calculator)

IV. Limbal Relaxing Incisions (LRIs)
   A. Helpful for <1.25 D mixed astigmatism
   B. Peripheral relaxing incision: Avoid going too central <8 mm; it causes coma.
   C. Donnenfeld or Nichamin nomograms at 11 mm ~600 microns typically
   D. LRIs excellent for astigmatism <1 D (0.5-1.0)
   E. Single incisions are often sufficient.
   F. Can combine with cataract extraction (CE) or after CE
   G. Femtosecond LRIs are very helpful for astigmatism <1 D.
   H. Can make open or closed incisions and titrate closed incisions postop

V. PRK/LASIK
   A. Helpful for astigmatism and sphere >1 D
   B. Mini PRK 7-mm epithelial removal diameter
      1. 25% quicker recovery
      2. Less persistent epithelial defect risk
      3. Less discomfort
   C. PRK-LASIK: Do lens trial prior to surgery.
      1. Trial lenses In the lane works great to demonstrate the improvement.
      2. Soft contact lens trial
      3. Consider a temporary spectacle lens if unsure.
      4. Test level of trial satisfaction *prior* to PRK/LASIK.

VI. PRK vs. LASIK
   A. PRK for post-LASIK eyes
   B. LASIK for healthy corneas, especially for quick recovery

VII. Rule Out Irregular Astigmatism
   A. Keratoconus
   B. Contact lens corneal distortion
   C. These conditions create a suboptimal outcome; contraindicated with multifocals

VIII. The Fine Art of Refining Premium IOLs
   A. Correct
      1. Posterior capsule opacification
      2. Ametropia
      3. Astigmatism
   B. Inform patient preoperatively that post-IOL refinements may be needed.

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Descemet Membrane Role in Modulating Corneal Wound Healing

Steven E Wilson MD, Carla S Medeiros MD PhD, Paramananda Saikia PhD, Rodrigo Carlos de Oliveira MD, Luciana Lassance PhD, and Marcony R Santhiago MD PhD

I. Prior studies have demonstrated that injury and defective regeneration of the epithelial basement membrane (EBM) underlies the development of stromal scarring (fibrosis) that occurs after injuries, infections, surgeries such as photorefractive keratectomy, and corneal diseases.

II. In a *Pseudomonas aeruginosa* infection model, both EBM and Descemet membrane were injured in most rabbits.

   A. The EBM repaired by 2 months, and anterior stromal fibrosis resolved due to apoptosis of myofibroblasts and resorption of disorganized extracellular matrix collagens, etc. produced by the myofibroblasts.

   B. The Descemet basement membrane did not regenerate, and myofibroblasts and fibrosis persisted in the posterior cornea for at least 4 months.

III. Study in rabbits designed to answer the question "Is the injury to the endothelium or the Descemet basement membrane, or both, important in the development of posterior fibrosis in the cornea?"

   A. Six rabbits had injury to an 8-mm diameter circle of endothelium without damage to Descemet basement membrane using a smooth-tip olive cannula. All corneas developed temporary edema, but no scarring developed and the corneas returned to normal by 1 month after the injury.

   B. Six rabbits had Descemet basement membrane–endothelial removal over an 8-mm area of the posterior cornea (as in Descemet membrane endothelial keratoplasty [DMEK]).

      1. All corneas developed edema and posterior scarring populated with myofibroblasts and the disordered extracellular matrix secreted by these cells.

      2. No evidence of repair of Descemet basement membrane at 1 month after injury

IV. The Descemet basement membrane, like the EBM in the anterior cornea, binds transforming growth factor (TGF) beta and prevents it from entering the corneal stroma at high levels, where it will drive the development of myofibroblasts from both keratocyte-derived and bone marrow–derived (fibrocytes) precursor cells.

   A. TGF beta is present at high levels in the aqueous humor (Streilein et al., 1991).

   B. When the Descemet basement membrane is injured and not replaced, TGF beta enters the posterior cornea at high levels and drives the development of myofibroblasts.

   C. These myofibroblasts produce disordered extracellular matrix that persists until the Descemet endothelial complex is surgically replaced (penetrating keratoplasty [PKP], Descemet-stripping automated EK [DSAEK], or DMEK).

V. Clinical Implications

   A. When performing DSAEK or DMEK, avoid gaps between recipient and donor Descemet membrane that could trigger posterior fibrosis.

   B. If DSAEK or DMEK grafts become dislocated, they should be promptly replaced.

   C. In corneas that have descemetorrhexis without replacement (for example in Fuchs dystrophy), posterior corneal fibrosis can develop.

   D. In corneas that develop posterior fibrosis after disorders like herpes simplex virus or cytomegalovirus, DSAEK or DMEK could be beneficial in treating fibrosis once the infection is cleared and inflammation is controlled.

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Managing LASIK Complications

Sonia H Yoo MD

Synopsis

I will show some of the surgical complications that occur with femtosecond laser flap creation: centration difficulties, suction loss, interface entry issues, vertical gas breakthrough, and flap tears. Additionally, I will show flap interface inflammation and discuss how to distinguish this from infection and epithelial ingrowth.

Managing SMILE Complications

Dan Z Reinstein MD

Suction Loss

The femtosecond cutting is the most critical part of the procedure. While a suction loss rarely leads to the patient not receiving a complete treatment, it is obviously better if a suction loss can be avoided. The VisuMax software is programmed to handle a suction loss; this is known as the Restart treatment module. This wizard-style software system will provide a recommendation for continuing the procedure following a suction loss.

- Lenticule interface, first 10%: Restart SMILE with the same settings.
- Lenticule interface, 10%-100%: Convert to LASIK with flap thickness equivalent to the planned cap thickness.
- Lenticule side cut: Restart SMILE from the lenticule side cut with the same settings.
- Cap interface: Restart SMILE from the cap interface with the same cap thickness.
- Small incision: Restart SMILE from the small incision.

However, there are some scenarios where following the actions provided by the internal software is *not* recommended.[1] One important scenario to consider is when it is possible that femtosecond cutting was continued as suction was lost and the eye moved away from the contact glass.[2] This will result in the interface tracking upward through the cornea, thus increasing the risk of tissue slivers or false plane creation during interface separation if further interfaces are created. Therefore, whether conversion to LASIK may be a better option should be carefully considered.

Black Spots in Femtosecond Bubble Pattern

Dark spots represent areas where there may not have been effective femtosecond cutting, which can be more difficult to separate. Significant manual separation can lead to irregularities in the lenticule that manifest as irregularly irregular astigmatism after surgery.

Dark spots can be associated with the following:

- Very low energy
- Stromal geometry
- Debris or fibers on the contact glass or in the tear film (eg, meibom)

If there are black spots or translucent lines affecting the bubble pattern, especially within the pupil borders and on the lenticule cut, it is highly recommended that you consider switching to LASIK.[2]

False Plane Creation

Creating a false plane, even when the bubble pattern is normal, was more common in the early years of SMILE, before SMILE-specific instruments were designed. Even with blunt instruments it is important to monitor interface creation intently at all times. If a false plane is created, the procedure should be aborted and layered corneal imaging should be obtained to create a plan for subsequent removal/treatment to decrease the chances of incomplete lenticule removal.[3]

Lenticule Remnants

Another possible complication of SMILE is leaving a lenticule remnant in the interface. A lenticule remnant is most likely to occur in cases where the separation was difficult, and it is more likely when extracting thinner, more delicate lenticules. However, these can also occur after lenticule separations that appear routine. Lenticule remnants can cause distortions and irregular astigmatism on topography, and consequently cause issues with quality of vision. Therefore, every care should be taken during surgery to ensure that the entire lenticule has been removed.

Lenticule recovery techniques include the following:[2]

- Sweeping the circumference of the lenticule border using the Separator bulb
- Using the built-in slit-lamp feature within the operating microscope
- Creating an air pocket by lifting the instrument to raise the cap away from the stromal bed to improve visibility of the stromal bed
- Using a reserve incision to improve instrument manipulation or change direction of force to help aid in removal
- Flooding the interface with an opaque suspension (eg, Kenalog-10) to demarcate the contours within the interface

Once removed, the lenticule remnant should be placed on the cornea together with the main body of the lenticule to check that the pieces of the puzzle fit together. If the pieces do not fit perfectly, then further investigation of the interface might be performed.

Cap Tears and Perforations

As in LASIK, there is the possibility of the separating instrument perforating the cap and creating a tear. These tears are most likely to occur at the small incision, with the most common cause being manipulation of the surgical instrument. When the instrument is fully inserted into the interface, it is important to rotate the shaft so the elbow does not stress the wound, as opposed to making lateral movements of the instrument. A small, or even large, incision tear very rarely has any effect on the final outcome as long as it is carefully replaced and repositioned in the same manner as any corneal incision or LASIK flap.

Cap Folds

The management of the cap starts during the initial slit-lamp evaluation by the surgeon directly after the procedure. The cap should be smoothed using heavy fluorescein staining to aid visualization of even the subtlest annular or linear nanofolds by evaluation of the negative staining pattern.[2] This slit-lamp technique can be repeated if necessary at the day 1 examination.

Atypical DLK: Sterile Multifocal Inflammatory Keratitis After SMILE

Diffuse lamellar keratitis (DLK) can occur after SMILE with the same classic presentation as after LASIK. However, inflammation can also present after SMILE with a unique appearance not typically seen after LASIK, appearing as small focal infiltrates scattered throughout the interface with or without a diffuse component.[4] This presentation is usually seen on day 1 after SMILE and can be alarming, given the focal appearance. So the index of suspicion for infection needs to be very high, and these cases need extremely close monitoring during the perioperative period.[5] These cases are managed similarly to classic DLK, with increased steroids and antibiotic coverage. However, focal infiltrates are still more likely to cause localized melting; thus the threshold for performing an interface washout should be lower than with classic DLK.

Epithelial Ingrowth/Implant

Epithelial ingrowth after SMILE can sometimes present as an "implant" rather than an "ingrowth," caused by stray epithelial cells being drawn into the interface. The ingrowth tends to be very small and rarely visually significant. Epithelial implants can be treated by washout and or cap scrape. For implanted islands that become elevated over time, focal Nd:YAG laser has been shown to speed absorption in most cases.[6]

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Topography-Guided Treatments

Topography-Modified Refraction in Laser Vision Correction

A John Kanellopoulos MD

The refractive error utilized as a globally accepted rule in laser vision correction applied to the cornea, either as LASIK, PRK, or even SMILE, has been the subjective refraction established by the dry manifest and/or in consideration of the cycloplegic manifest as well. The study of topography-guided excimer LASIK treatments internationally, and especially in highly irregular eyes, has shown that often the clinical refraction astigmatism amount and the axis can be very different when compared to the topographic astigmatism. The subjective measurements present usually less cylindrical power and different axis.

Our lengthy clinical experience in treating irregular corneas with topography-guided excimer ablations has been reported in dozens of peer-reviewed publications, and over 1000 cases have been careful analyzed and evaluated for this principle. Our early experience in highly irregular corneas in procedures such as the Athens Protocol for keratoconus and ectasia resulted in improved outcomes when topography-guided suggested data were used instead of subjective clinical measurement; thus we opted to modify accordingly the subjective refractive data used for actual surgical correction.

Topography-guided treatments in routine, otherwise healthy myopic cases were studied carefully in the recent FDA study, which established significant superiority in visual outcomes when compared to wavefront-optimized treatments and even wavefront-guided treatments. We have instituted the knowledge from treating irregular corneas and studying topography-based modification of the up-till-now "gold standard" clinical refraction. We thus introduced the principle of topography-modified refraction, or TMR, in a contralateral eye study and found that refraction modification in regard to cylinder amount and axis, when topography-guided treatments are used, may offer better outcomes than those documented in FDA studies mentioned above.

This clinical example may help explain the thought process behind TMR: The clinical refraction is −6.50 −0.50 @ 45 degrees (135 degrees on the + cylinder axis). When the topographic data are fed into the software (WaveLight/Alcon platform, EX 500 excimer laser) and the refraction is set to 0 sphere and 0 cylinder, we can view the topo-guided treatment (Figure 1, image on the right) that the device will apply to normalize this cornea in regard to the visual axis of the patient, as defined at the time of topography capture (image on the left), and adjusted intraoperatively to match the same center with tracking adjustment to include cyclorotation if needed. The angle kappa is defined by the specific topography (left image, in the read-out circled on the x and y axis): this is the displacement of the pupillary center from the vertex. Thus this regular astigmatism, noted on topography and in regard to the pupil, functions as "irregular" or "prism" to the patient, who views through the vertex point. The topography-guided treatment will reshape the

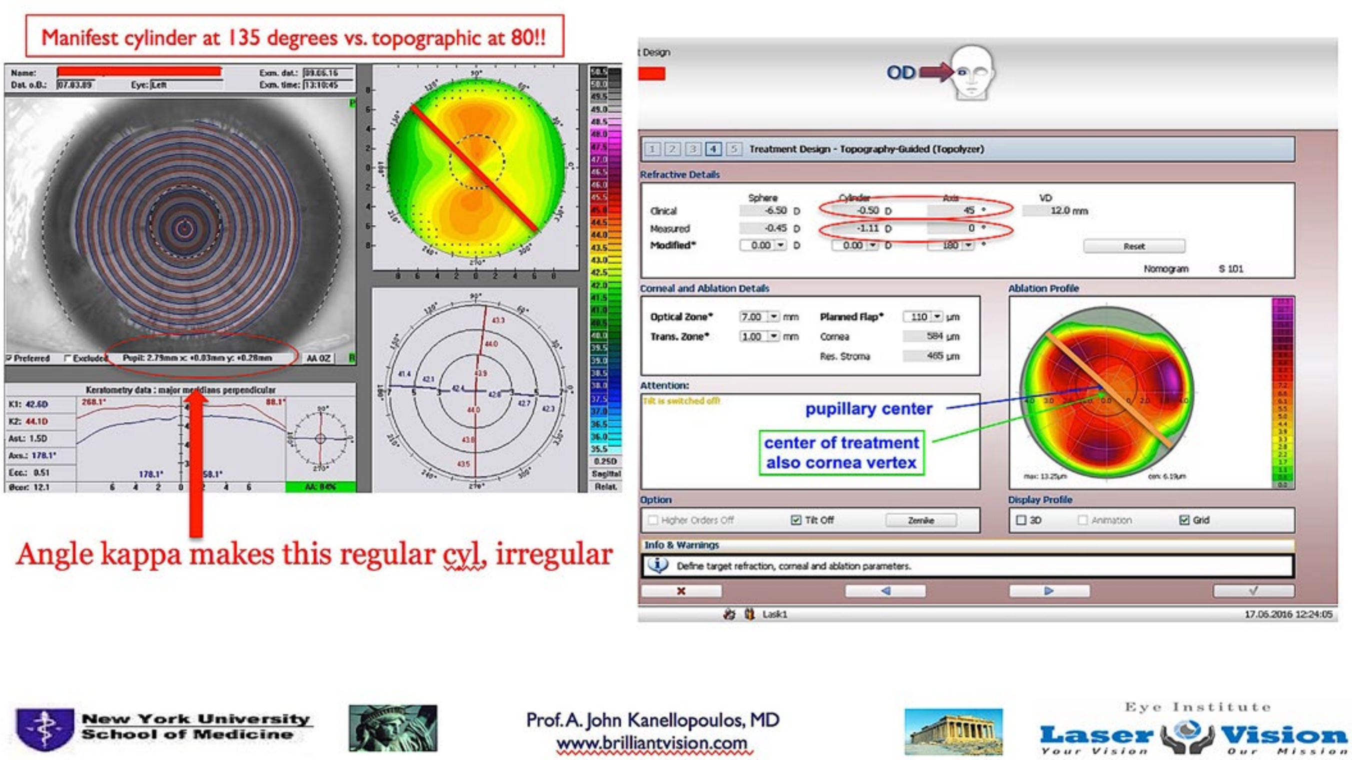


Figure 1.

anterior cornea to become highly regular in regard to the vertex and essentially the visual axis of the patient. Thus the clinical refraction, which may have included compensatory cylinder chosen by the patient in order to practically improve the visual function, may change significantly.

This is the exact point that we argue: that if topography-guided treatment is chosen, the surgeon is compelled to consider adjusting the amount and axis of cylinder treated according to the topography-guided suggestion, noted as "measured" in the middle of the 3 refractions illustrated on the right image (cylinder −1.11 at axis 0, or axis 90, on the + cylinder axis). This 45 degree difference in axis and 0.6 D difference in amount is compelling and needs to be confirmed by posterior corneal astigmatic data, such as provided by a Scheimpflug-based tomography analysis of the cornea, as was done in this case. The topography-suggested data were used here with TMR: −6.25 −1.00 @ 0 degrees; uncorrected distance visual acuity at 3 months was 20/10.

In last winter's ESCRS meeting, held in Athens, Greece, in February 2019, we had the opportunity to report for the first time our interim data on a randomized prospective study comparing the above concepts (see Figure 2).

One eye was treated topo-guided with the clinical refraction, while the other was randomized to be treated either with 50% TMR (50% adjustment of the cylinder amount and axis difference between the clinical and topo-measured cylinder) or 100% TMR (treatment of the full cylinder amount and axis defined by the topo-guided treatment software). The interim data are quite impressive and illustrated in Figure 3: both the 50% and 100% TMR eyes outperformed significantly the standard refraction–treated eyes! The difference between 50% and 100% was substantial, but not as significant as when comparing either to the standard manifest refraction treatment.

We hope that this work will make surgeons more perceptive to the sensitive principles of topography-guided treatments and potentially employ them as an adjunct for improving visual outcomes in laser refractive surgery.

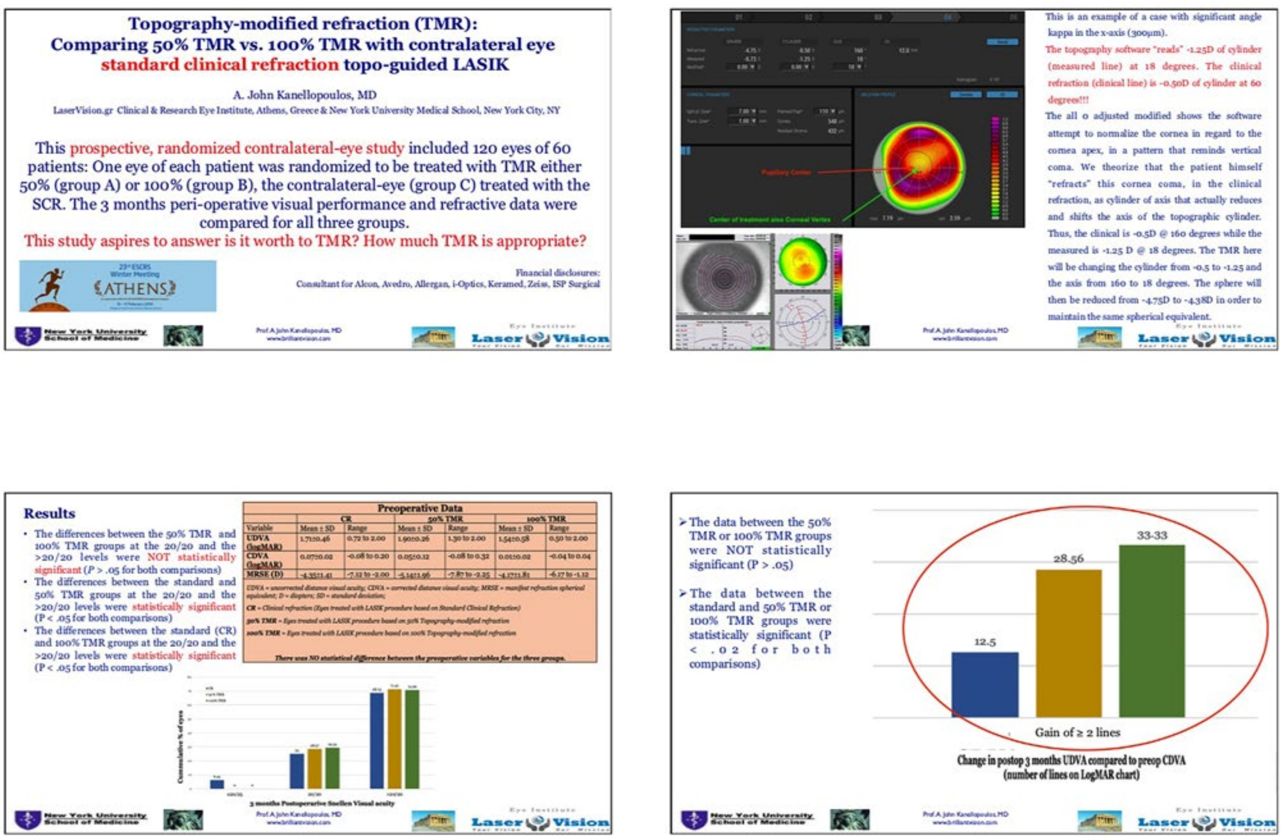
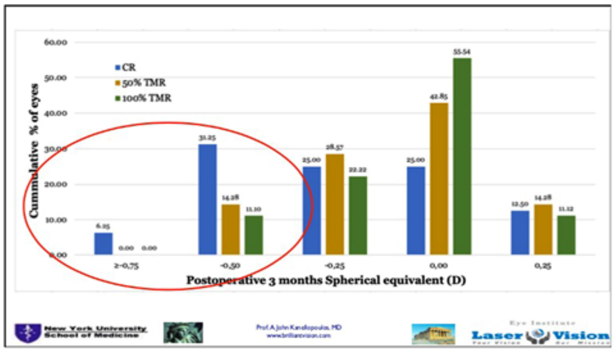
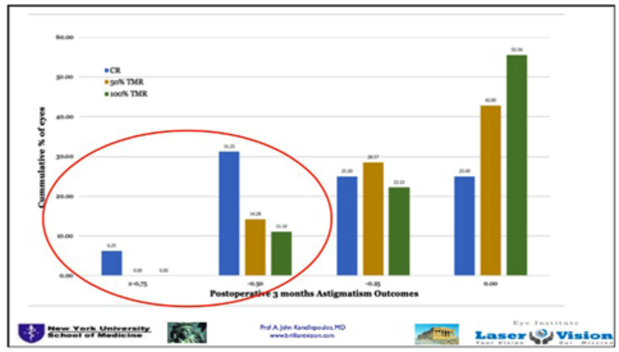


Figure 2.





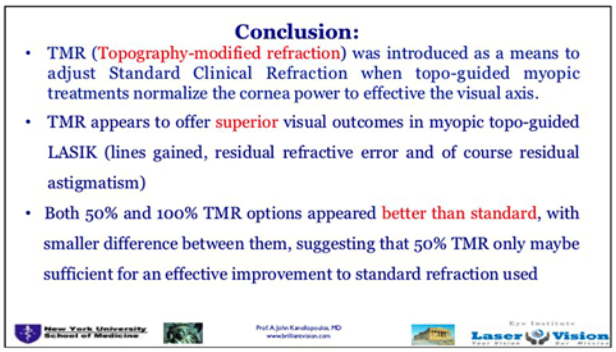


Figure 3.

TMR Pearls

Compare the corneal and refractive astigmatic data.

The corneal and refractive astigmatic data may not be identical. In that situation, if you're using topography-guided LASIK, you can decide whether to "blend" the corneal and clinical refraction data, modifying the treatment amount and axis of astigmatism based on the topographic data. This is what we've described in the past as a topography-modified refraction or TMR adjustment of the topography-guided treatment. On rare occasions you may find that you also need to account for posterior corneal astigmatism, but this is seldom an issue.

Remember that altering the topography changes the spherical refraction.

A common mistake that surgeons new to this technology make is thinking that topography-guided treatment will give them the perfect outcome when combined with the clinical refraction. If there's a significant amount of topographic correction, the refractive outcome will change. It won't be what you'd expect if you had treated using wavefront optimized. This is certainly true when correcting astigmatism; when we change the amount of astigmatism, an appropriate adjustment needs to be made to the spherical equivalent. If we decrease the astigmatism by a diopter, we'll need to adjust the spherical correction to take this into account.

The clinician can see the amount of change that will be created by the topography-guided treatment by looking at the ablation plan with the amount of sphere and cylinder set to 0. This will clearly show what the laser is going to do for that specific cornea in order to normalize it. This will allow the clinician to adjust the spherical correction accordingly.

If a clinician finds this daunting, it's probably best to treat using a more familiar technology such as a wavefront-optimized procedure. If a problem arises in the future, you can refer the patient to an expert in topography-guided treatments to address it.

Take advantage of the training that's available.

Maximizing vision with this technology can be complicated. I have had the honor to chair and work along with several other world-recognized topo-guided "aficionados" in offering courses on this valuable subject just prior to all of the major meetings over the last 3 years. We spend a full 8 hours in these day-courses, going through sample cases, step-by-step, to help clinicians become familiar with all of the parameters involved in using this technology and actually designing treatments on their own. In the meantime, I would invite anybody who is interested in this to visit the pertinent website at: http//www.topo-guided.com.

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Medical Treatment of Presbyopia

Sheri Rowen MD

NOTES

Eyedrops for Presbyopia: The Next Step

David Smadja MD

NOTES

Future Directions of Cornea-based Laser Vision Correction

Ronald R Krueger, MD

A. Advanced Customized Photoablation with LASIK

B. Next Generation Photodisruption with SMILE

C. No Touch and No Aberrations with Transepithelial PRK

D. Stromal Laser Induced Refractive Index Change (LIRIC)

E. Epithelial Refractive Index Change with Nanodrops

F. Tissue Addition with Lenticular Implantation Keratoplasty (LIKE)

Identifying the Pre-ectatic Cornea: Big Steps, Missteps, and Next Steps

J Bradley Randleman MD

Big Steps

- Recognizing postoperative ectasia as a concern
- Identifying topographic findings associated with abnormal corneas and ectasia risk
- Identifying additional risk factors for ectasia after LASIK
- Using combined metric screening tools
- Scheimpflug imaging
- Epithelial mapping

Missteps

- Underestimation of ectasia risk in the early days of LASIK
- Overestimation of ectasia risk / being overly concerned about a rare phenomenon
- Over-reliance on unproven screening tools
- Over-reliance on indices rather than detailed image analysis
- Underestimation of ectasia risk again (SMILE)
- Over-reliance on pseudo–corneal biomechanical metrics

Next Steps

- Performing detailed image analysis / using all data available
- Utilizing combined technology screening: Placido and Scheimpflug, Scheimpflug and epithelial mapping, and others
- In vivo biomechanics: OCT, Brillouin, Speckle interferometry, and others
- Genetic testing
- Alternative, tissue-sparing treatment strategies for refractive errors
- Moving slowly / using identical screening criteria for new procedures until there is evidence that procedures have different biomechanical impact

Understanding Percent Tissue Altered as a Risk Factor for Ectasia After Excimer Laser Surgery

Marcony R Santhiago MD

Introduction

Postoperative corneal ectasia is a sight-threatening complication, most likely associated with a reduction in the corneal structural integrity below the threshold required to maintain its shape. In the absence of early morphological signs of ectatic corneal disorders, ectasia could theoretically occur when a relatively normal cornea is weakened below a safe threshold. Understanding, recognizing, and accepting its risk factors are crucial steps toward a significant reduction in the occurrence of this adverse event.

Percent tissue altered (PTA) determines the relative amount of biomechanical modification that has occurred after excimer laser refractive surgery. For LASIK, PTA is described as: *PTA = (FT + AD)/CCT,* where FT = flap thickness, AD = ablation depth, and preoperative CCT = central corneal thickness. Studies suggest this metric may more accurately represent the risk of ectasia than the individual components that comprise it.

Although most patients who have developed ectasia after LASIK or PRK have had identifiable risk factors that placed them at higher risk for this complication, ectasia cases in patients with normal preoperative topography have still been the source of extensive investigation. Santhiago et al coined the term and first investigated and consistently determined the association of a high value of PTA and ectasia risk. This article reviews the PTA concept and discusses the role of PTA in ectasia after LASIK in eyes with normal and suspicious topography, the relative contribution of flap and AD, and its role in PRK and the correct way to interpret, understand, and apply it as a risk factor (not a screening method).

The Concept of PTA

As corneal strength is not uniform throughout the central cornea, with a progressive weakening in the posterior two-thirds, we hypothesized that the relative extent of tissue alteration would play a more representative role on the postoperative weakening than the same cut-off of residual bed for all patients. There is an integrated relationship between preoperative CCT, AD, and flap thickness in determining the relative amount of biomechanical change that has occurred after a LASIK procedure, and PTA better describes this interaction during excimer laser refractive surgery.

One of our first studies in this context investigated changes in novel biomechanical descriptors after different levels of myopic femtosecond LASIK in normal eyes, and revealed the PTA as a much stronger predictor of LASIK-induced biomechanical change compared to AD or residual stromal bed (RSB). These findings were an important background to specifically investigate the relationship between PTA and the risk of ectasia after LASIK.

Association Between PTA and Ectasia in Eyes With Normal Topography

In order to remove bias and better understand the potential, and specific, association between PTA and ectasia risk, we conducted a comparative case-control study including eyes that developed ectasia after LASIK for myopia and myopic astigmatism with strictly normal bilateral preoperative Placido disk-based corneal topography. With a high odds ratio, the study revealed that in eyes with normal preoperative topography, a PTA of 40% or higher is, by definition, a risk factor for ectasia after LASIK for myopia. PTA presented not only a higher odds ratio value in eyes that developed ectasia compared to traditional risk factors such as RSB, CCT, high myopia, AD, or age, but also a higher prevalence.

As well as in the original study, the validation study published this year also revealed mean values of previously recognized risk factors such as RSB, CCT, and age that would place this average patient at low risk for post-LASIK ectasia, except for the mean high PTA value. Endorsing the presence of similar characteristics in these previously regarded low-risk eyes (except for the high PTA) that otherwise did develop ectasia. These findings, concurrently with the high odds ratio value, validate a high PTA as a risk factor and possibly explain why ectasia occurred in corneas with RSB and thickness values within acceptable safety standards, even with normal topography before LASIK, if the combination of these factors resulted in a high percentage of altered tissue.

The main explanation for this scientific finding most likely lies in the relative percentage contribution of the anterior stroma to the total corneal strength, which is modified after excimer laser refractive surgery. As corneal tensile strength presents an inhomogeneous distribution throughout the central corneal, removing the anterior part of the stroma may induce corneal weakening in increasing proportion as the threshold of 40% is reached and crossed. As compared to specific RSB or CCT cut-off values, PTA likely provides a more individualized measure of biomechanical alteration because it considers, at the same time and in one metric, the relationship between thickness, tissue altered through ablation and flap creation, and ultimate RSB thickness.

In a recent computational study, Dupps and Seven also provided indirect validation of PTA as a risk factor for ectasia. They investigated the biomechanical strain as a structural susceptibility metric for corneal ectasia in a large-scale computational trial and found that PTA more strongly correlated to the change in mean maximum principal (MPS) strain and that PTA presented a stronger relationship with surgically induced strain change after myopic refractive surgery compared to RSB. MPS represents the maximum amount of tensile strain at that material point under the modeled loading conditions, and higher strains are associated with a higher risk of material failure when subjected to tensile deformations.

The main advantage of the PTA method lies in its simplicity as it incorporates the information about flap thickness, AD, and CCT. It should be highlighted that PTA already considers the optical zone in each calculation—as Munnerlyn's equation for AD is *[(optical zone)2 x diopters]/3*—and indirectly informs about the residual stroma that is left not altered, all in one single variable.

Relative Contribution of Flap Thickness and AD to PTA

The results of our studies further corroborated that the measured central flap thickness was not thicker than estimated in most eyes developing ectasia after LASIK ($P = .104$). Moreover, a previous study revealed eyes with thick flaps that developed ectasia had a significantly higher PTA and a statistically greater proportion of PTA derived from the AD.

Role of PTA in Eyes With Suspicious Topography

PTA will obviously have a different impact in eyes with topographic irregularities, since those corneas are by definition already showing evidence of weakening prior to any tissue removal. Previous studies have arguably demonstrated that abnormal corneal topographic patterns are the most significant risk factor for postoperative ectasia. In a study specifically conducted on eyes with suspicious topography, we showed that less tissue alteration, or a lower PTA value, was necessary to induce ectasia in eyes with more remarkable signs of topographic abnormality. PTA again provided better discriminative capabilities than RSB for all study populations.

PTA for PRK

The relationship between PTA and ectasia after PRK was not the scope of our studies simply because the ideal scientific context to specifically investigate this association would include eyes that developed ectasia after PRK with strictly preoperatively bilateral normal topography. However, the vast majority of these specific cases of ectasia after surface ablation occurred in eyes with suspicious, or abnormal, topography preoperatively.

However, although we should not easily transpose the findings obtained investigating eyes submitted to LASIK to eyes submitted to PRK, if the preoperative topography is genuinely healthy, the limits may be potentially higher in PRK because of its surgical structural differences, as there is no flap cut or peripheral impairment of corneal fibers. For PRK, PTA can be described as *PTA: (epithelium thickness + AD)/CCT*. The epithelial thickness could be estimated at 50 microns in healthy eyes. Average epithelial thickness does not vary significantly by overall corneal thickness, so the relative stroma altered in any PTA measurement will change only slightly (less than 1%) with the standard variation of epithelial thickness.

Understanding a High PTA as a Risk Factor for Ectasia After LASIK and How to Use It

PTA is a risk factor for ectasia after LASIK and not a screening method. A risk factor determines a relationship and has nothing to do with symptoms, whereas a screening detects disease in asymptomatic individuals. A risk factor has its definition and relevance determined through the analyses of odds ratios or relative risk values that should be higher than 1. A screening method, on the other hand, has its relevance investigated through sensitivity and specificity and ideally should present a high sensitivity.

When present, a risk factor will never predict an event, and more importantly, it will never become and should not be mistaken for a screening method. For example, a high PTA merely means that these eyes carry a higher risk for ectasia compared to those with a low PTA. This risk factor should not be mistaken for a screening method and therefore not investigated through sensitivity tests. Conversely, a screening method, when positive, detects the disease and may become, from that point on, a risk factor for something else. For instance, we need highly sensitive tests to identify early forms of keratoconus. When detected (positive test for disease), this individual will have a risk factor for post-LASIK ectasia. These concepts, however, should not be interchanged, and this is evident when we investigate the other risk factors that are related to ectasia and have nothing to do with keratoconus or any other disease, like PTA or RSB. These are the fundamental differences between risk factors and screening methods, and the differences impact how we interpret and investigate them.

The risk of underestimating risks will always be higher than the risks of accepting them. However, the fact of an event occurring rarely has another significant implication; even if the risk factor increases the frequency of the event, it will still be rare. In other words, the denominator will always be a large number. Therefore, risk factors should be interpreted as a warning signal and correlation estimation, which may or may not impact the decision. A risk factor should be incorporated into the surgeon's mindset as an ancillary tool in identifying eyes that are at higher risk for an adverse event. It should be considered together with the surgeon's experience, though not blinded by it, in association with the benefits of the procedure and balanced by the prevalence of the adverse event in the discussion.

Given the elective nature of LASIK, it seems logical that the balance of risk acceptance should be weighted toward minimizing risk, especially when other excellent procedures are available for refractive correction. For example, we have recently showed that a high-myopic PRK with application of mitomycin C in the eyes at higher risk of developing ectasia because of high preoperative PTA was demonstrated to be a safe and effective alternative to the LASIK procedure.

In conclusion, our sequence of studies validated a high PTA value as a risk factor for ectasia in eyes with normal topography. As compared to specific cut-off values of RSB or CCT, PTA likely provides a more individualized measure of biomechanical alteration after LASIK. None of the risk factors applied in refractive surgery have gone through these strict methods of identification and validation.

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Analysis of Corneal Structural Response and Ectasia Risk in Myopic Laser Refractive Surgery

William J Dupps MD PhD

NOTES

Subclinical Keratoconus Detection by Pattern Analysis of Epithelial Maps with OCT

David Huang MD PhD

Detect and differentiate between keratoconus, warpage, and other conditions common in LASIK candidates using corneal and epithelial map measurements with OCT

I. Corneal anterior topography is not sufficient for detection of early keratoconus among LASIK candidates.[1]

   A. Topography may be normal in forme fruste keratoconus (FFK) due to epithelial masking.

   B. Contact lens–related corneal warpage and dry eye can mimic keratoconus on topography.

II. OCT epithelial thickness map and pachymetry map provide additional information to aid in more accurate diagnosis of subclinical and FFK.[2]

   A. OCT is the only noncontact imaging technology with sufficient resolution to measure epithelial thickness.

   B. Confocal microscopy and ultrahigh-resolution ultrasound both require contact.

   C. Scheimpflug camera cannot resolve the epithelium.

   D. Keratoconus causes coincident focal thinning of epithelium and pachymetry on OCT corneal maps.[3]

III. Step-by-Step Guide to Interpreting OCT Corneal Maps

   A. Parameters

      1. Pachymetry map: minimum (Min), minimum-maximum (Min-Max), superonasal-inferotemporal (SN-IT)

      2. Epithelial thickness map: standard deviation (Std Dev)

   B. Pattern analysis

      1. Concentric thinning

      2. Coincident thinning

IV. Clinical Study

   A. Detection of subclinical and FFK

   B. Differentiation from warpage and dry eye[4]

V. OCT Systems for Corneal Epithelial Mapping, FDA-Cleared

   A. Optovue, Inc.

      1. Avanti (9-mm map)

      2. iVue (6-mm map)

   B. Carl Zeiss Meditec, Inc.: Cirrus (9-mm map)

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Influence of Corneal Posterior Astigmatism in Normal Eyes and Keratoconus

Wallace Chamon MD

NOTES

Integration of Scheimpflug-Based Tomography and Biomechanical Assessments

Paolo Vinciguerra MD

Introduction

The evaluation of corneal biomechanics has significantly improved over the last decade as a result of its increasing importance in the diagnosis and treatment of diseases such as keratoconus, its role in modeling of refractive surgery, and improvements in technology. Furthermore, the detection of mild or subclinical forms of ectasia has gained increased relevance because these cases are at very high risk of developing iatrogenic ectasia (keratectasia) after corneal laser vision correction (LVC) surgeries. After the analysis of corneal shape, clinical biomechanical assessment has been considered as an additional tool for enhancing the overall accuracy of the process of identifying mild forms of ECD, along with the characterization of the inherent susceptibility of the cornea for ectasia progression.

Objective

The aim of the presented paper is to introduce the Tomography Biomechanical Index (TBI), which aims to combine tomography and biomechanics to improve ectasia detection.

Methods

More than 770 patients were included, enrolled from 2 clinics: Instituto de Olhos Renato Ambrósio in Rio de Janeiro (Brazil), and the Vincieye Clinic in Milan (Italy).

Included patients were:

- Normal patients
- Frank keratoconus patients
- 72 eyes from 94 patients with very or highly asymmetric clinical ectasia (VAE, Group III: E-VAE), whose fellow eyes presented with normal topography (Group IV: NT-VAE)

All patients had complete eye examination, including Pentacam and Corvis ST (Oculus Optikgeräte GmbH; Wetzlar, Germany).

The data were evaluated and combined using different artificial intelligence (AI) methods, including logistic regression analysis with forward stepwise inclusion, support vector machine, and random forest, to optimally combine tomography and biomechanics parameters to better separate healthy from keratoconic eyes.

Results

A TBI was created using random forest, which provided the best results.

The main result was the improved ectasia detection using TBI. Specifically, the AUROC of the TBI for spotting ectasia (Groups II, III, and IV) was 0.996 with cut-off of 0.48. TBI provided 98.8% specificity with 96.2% sensitivity. TBI had 100% sensitivity to detect frank ectasia cases (AUROC = 1.0; Groups II and III). When evaluating the ability to detect the normal topography eyes from patients with clinical ectasia in the fellow eye, optimization of cut-off value to 0.29 provided 90.4% sensitivity with 4% false positives (96% specificity; AUROC = 0.985).

Discussion

The TBI included indexes from Pentacam HR and Corvis ST exams and provided higher accuracy for detecting ectatic corneal diseases than all previous analyzed parameters, including CBI. The random forest method provided the most efficient strategy for developing TBI.

We suggest the routine use of TBI in clinical practice to detect ectasia.

Advances in Corneal Topography

Stephen D Klyce PhD

Introduction

Corneal topography has become a standard of care in anterior segment clinical diagnostics. With technologic advances, corneal topographers have evolved from Placido-style and grid-based reflection instruments to the addition of slit scanning for full-thickness corneal evaluation to interferometry-based OCT. Topographers are now available as combination devices that, for example, provide corneal topography plus ocular aberrometry and refraction, and corneal topography providing corneal thickness and axial length. One of the major recent advances is the miniaturization of a corneal topographer that sits on a slit lamp and stores its exams on a cloud-based server.

Corneal Topography and AI

While modern corneal topographers have matured over the three and a half decades since the introduction of computerized analysis,[1] and the two and a half decades[2] since the first augmented intelligence-based keratoconus screening systems were introduced, interest in AI and teleophthalmology is starting to blossom. Yet the accurate detection of those corneas at risk for ectasia after refractive surgery remains a significant enigma.

Mixed datasets derived from corneal tomography and OCT[3] or air puff biomechanical measures[4] have advanced our potential for improved recognition of corneas at risk for developing post–refractive surgery ectasia. In the future, the creation of large cloud-based, anonymized datasets comprising corneal topography examinations from varied global populations will provide the opportunity to develop advanced algorithms.[5] Perhaps there are nonintuitive, subtle clues in corneal data that can be ferreted out with unsupervised deep learning techniques that will better identify at-risk subjects and at the same time teach us what we should have been looking for all this time!

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Update in Corneal Crosslinking: Where Are We Now?

Theo Seiler MD PhD

NOTES

Update on Emerging Accommodating IOLs in Early Development

Stephen D McLeod MD

Introduction

By definition, accommodating IOLs produce actively variable lens convergence power so as to enhance visual function at different working distances. Numerous optical strategies are available to achieve this change, including change in optic position, change in lens curvature, and change in refractive index or optic power.[1]

Change in Optic Position

Anterior displacement of the IOL optic will result in a myopic shift and thus improved near vision. This has been accomplished by hinged designs that allow forward optic displacement, either by release of zonular tension or by vitreous pressure increase during accommodative effort. The disadvantage of this approach is that the amount of accommodation achieved is influenced not only by the degree of displacement but by the power of the optic, thereby limiting accommodative amplitude for low-power implants.

Change in Lens Curvature

Change in lens curvature offers potentially a far more powerful accommodative mechanism than does single optic displacement. Most current designs exploring this option employ systems wherein accommodative effort initiates fluid displacement from a reservoir to the lens optic, leading to curvature change of a distensible optic.

Change in Optic Power

Current strategies have employed a change in the orientation of optical elements that leads to focus power change, driven by accommodative effort that is mechanical (ie, driven by the ciliary body). Others rely upon a change in surface characteristics that is electrically activated (ie, triggered by pupillary miosis).[3]

All of these strategies must address common challenges, such as accommodative response time, rest state refraction, and persistence of function over time, but ongoing research promises ultimately to offer lens designs that produce improved visual function over the full range of focus.

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Residual Astigmatism After Toric IOL Implantation

George O Waring IV MD

NOTES

IOL Scaffold

Yuri McKee MD

NOTES

Glued IOL: Yamane Techniques

Eric Donnenfeld MD

The glued IOL technique and the Yamane technique are two different methods for scleral fixation of a 3-piece posterior chamber IOL.

A Surgical Technique for Glued IOL

Using a crescent blade, the first step is to create 2 scleral flaps 180° apart and then create 2 sclerotomies 1.5 mm posterior to the limbus and under the scleral flaps using an MVR blade. After placing a dispersive ophthalmic viscosurgical device (OVD) into the anterior chamber and an anterior chamber maintainer to prevent collapse of the globe, pars plana vitrectomy is performed to separate vitreous from the IOL, taking care to avoid exerting vitreous traction. It may be helpful to inject triamcinolone to help demarcate vitreous and simultaneously control postoperative inflammation.

The posterior chamber IOL is then inserted into the anterior chamber. The CT Lucia IOL is particularly effective in that the haptics are extremely flexible. Using 2 microforceps introduced into the eye through a limbal incision and one of the sclerotomies, the handshake technique is used to pass one of the haptics from the anterior chamber into the posterior chamber for externalization through the sclerotomy.

It is then helpful to have an assistant hold the first haptic while the second haptic is being externalized. Or one may attach a silicone retention slider from an iris hook onto the end of the externalized haptic to prevent its slippage while the handshake technique to grasp and deliver the second haptic through the sclerotomy on the opposite side is accomplished.

Once the haptics are externalized, they are placed into a scleral incision adjacent to the scleral flap. Then, the anterior chamber maintainer is removed and the scleral flaps and conjunctiva are fixed over the pockets with a small amount of fibrin glue.

Surgical Technique: Yamane Technique

The Yamane technique has many similarities to the glued IOL technique.

An ultrathin wall 30-gauge needle is employed. Using a toric marker, mark 0° and 180° for the main incisions. Then mark 2 mm from the limbus and 2 mm down from the main incision, and 2 mm from the limbus and 2 mm from the second incision. The 30-gauge needle is bent and placed at the initial marking and then tunneled 2 mm through the sclera prior to insertion into the anterior chamber. This is then repeated 180° degrees away.

The IOL is placed in the anterior chamber, and using microforceps, the haptic is inserted into the 30-gauge needle tip on both sides. The needles are then withdrawn, pulling the haptics through the sclera, where they are externalized.

A cautery is then employed to create heat to melt the tip of the haptic, creating a flange that is inserted back under the conjunctiva, fixating the IOL. Pulling on the haptics and shorting the haptic with cauterization can modify centration.

Pinhole Pupilloplasty

Amar Agarwal MD

The term "pinhole pupilloplasty" (PPP) is self-explanatory, as it states that a pinhole pupil can be achieved with the procedure of surgical pupilloplasty.[1] Technically, pupilloplasty has been described as a procedure employed for pupil reconstruction to prevent glare and photophobia. Currently, surgical pupilloplasty has found its application in the refractive aspect too, wherein decreasing the size of the pupil has been found to improve the visual and image quality.[1] The further application of PPP for achieving extended depth of focus is currently being investigated.

Principle of PPP

Pinhole visual acuity is the best possible vision that can be attained in a patient. PPP works on the same principle as a pinhole that helps to focus the central and paracentral rays in cases with higher-order corneal aberrations. PPP wards off the peripheral unfocused rays, thereby enhancing the visual quality and image (see Figure 1). It also works on the principle of Stiles-Crawford effect where the light entering the eye from the center of the pupil creates a greater photoreceptor response compared to light entering from the peripheral edge of the pupil.[2,3] As the pinhole is created, only central rays are focused that create a greater cone photoreceptor response.

Role of Purkinje Images in PPP

Theoretically there are 4 Purkinje images—P1, P2, P3, and P4—but clinically, as P1 and P2 overlap each other, only 3 are appreciated—P1, P3, and P4. The P1 image is right and upright, and it emerges from the anterior surface of cornea (see Figure 2). The P3 image, formed by the anterior surface of the lens or IOL, is large and upright, whereas the P4 image is formed by the posterior surface of the lens or IOL and is inverted. In a pseudophakic eye, the P1 image should be ideally placed between the P3 and P4 image. Deviation from this or proximity of the P1 image to either the P3 or P4 indicates the element of tilt or decentration of the IOL.

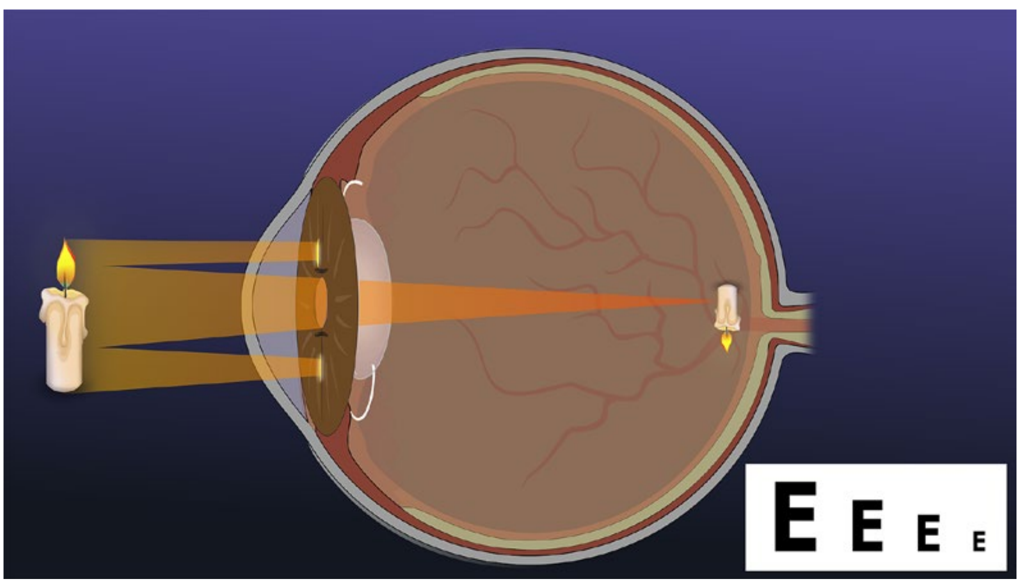

Figure 1. Animated image depicting the principle of pinhole pupilloplasty (PPP). A clear focused image is obtained when the rays from the central cornea are focused on the retina.

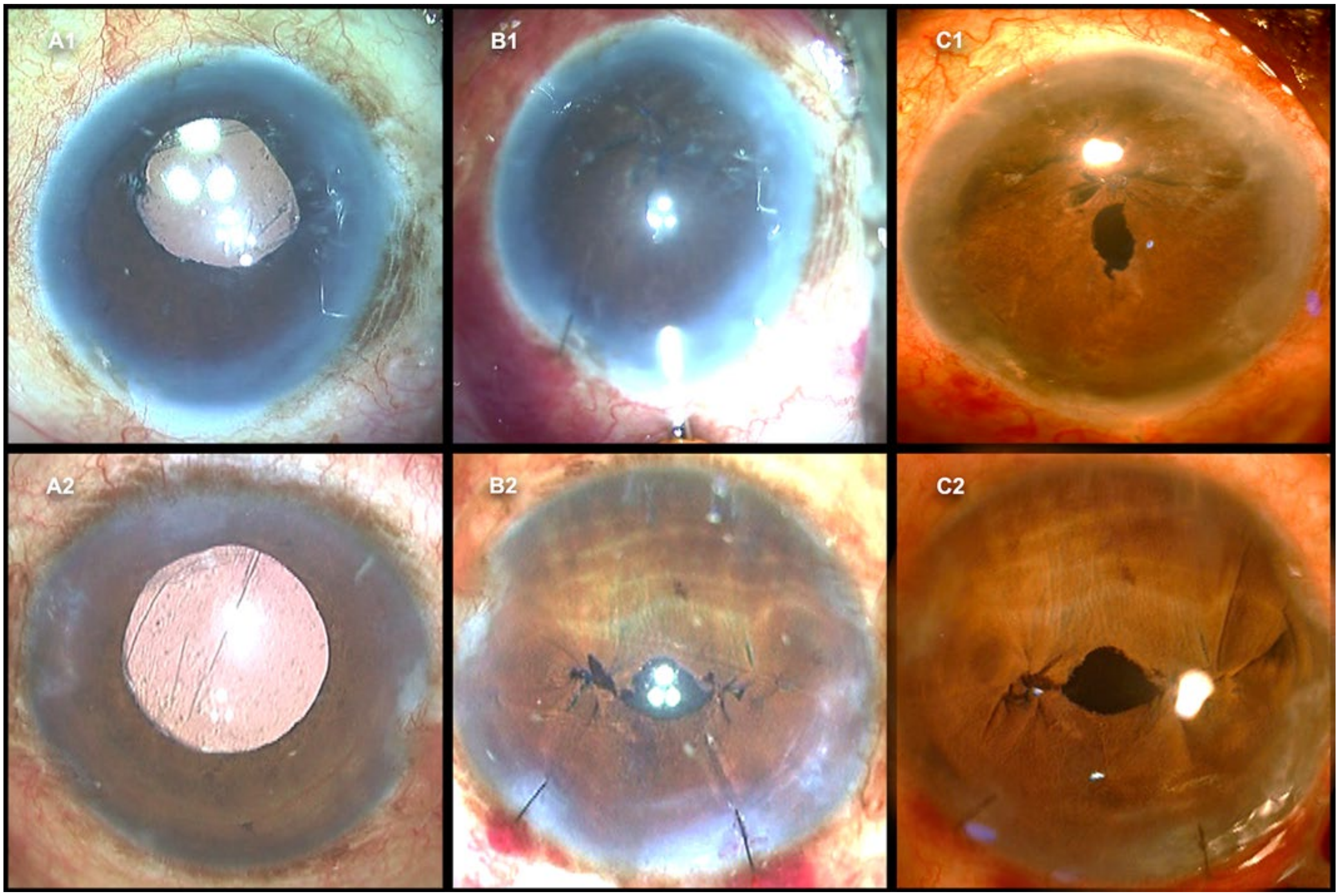

Figure 2. Clinical images of PPP in 2 cases. A1, A2: Preoperative image before PPP in a pseudophakic eye that denotes Purkinje images. B1, B2: Intraoperative image depicting a well-centered PPP with the P1 reflex engulfed by pupillary margin. C1, C2: Postoperative image as visualized on a slit-lamp examination.

Purkinje Image From Light Reflex of Surgical Microscope

Intraoperatively, the surgical microscope projects the light reflex on the eye that translates into the formation of Purkinje images. The Lumera microscope (Zeiss) projects 3 reflexes, and hence each Purkinje image is a collection of 3 light reflexes. The main illumination light is in the top of the triad, whereas the light from the 2 coaxial tubes forms the 2 side reflexes.[4] The iris tissue is aimed to surround the P1 reflex with the help of PPP, thereby achieving a customized small pinhole pupil.

Surgical Technique of Achieving a Pinhole

The procedure of PPP can be performed with any technique that can be a McCannel, Siepser, or Cerclage, but the authors employ the single-pass four-throw technique (SFT)[5] for achieving a pinhole pupil. A multiple-quadrant approach is necessary to achieve a pinhole pupil. The SFT procedure is performed, and 3 attempts or more are required to create a pinhole pupil. Often the iris tissue overlaps the P1 reflex of the Lumera microscope. Under these circumstances, a vitrectomy probe is used to reshape the pupil.

PPP and Chord Length Mu (µ)

With the procedure of PPP, the pupillary axis (PA) and the visual axis (VA) are brought close to each other. Angle kappa is the angular distance formed between the PA and the VA. Recently, instead of using the term "angle kappa," a more appropriate term, "chord mu," has been suggested. Chord length mu represents the chord length between the PA and the VA that has been found to decrease post-PPP. Chord mu is specifically defined by Chang and Waring as the chord distance between Purkinje 1 and the center of the pupil when viewed through the cornea. The cornea magnifies and deviates the ray, so the normal value as it appears through the cornea, known as an "apparent chord mu," is different from the actual chord mu that is measured at the plane of the iris. The IOLMaster and the LenStar measure apparent chord mu, with mean values of 0.30 mm nasal and about 0.05 mm inferior, so the mean chord mu is 0.30 mm on the hypotenuse. The standard deviation is about 0.15, so 97.5% of the population is less than 0.60 mm. This is the value that is taken into consideration when halos and glare from too big a chord mu begin. On the other hand, the Pentacam uses Schiempflug and gives the *actual* distance between the visual axis and the center of the pupil at the iris plane, that is, about 0.20 mm, with standard deviation of 0.11, so the value for Scheimpflug is 0.42 mm (not 0.60 mm).

Calculation of Chord Mu (µ)

Pentacam denoted the X and Y coordinates of the pupil center in its analytic report. Chord mu is calculated as the square root of the sum of X and Y coordinates. The following formula is applicable: $C = \sqrt{(x^2 + y^2)}$. The resultant value, C, denotes the value of chord mu.

Discussion

One should not make the pupil too small, otherwise diffraction would occur. That is why the ideal pinhole size is about 1.5 mm. The advantages of performing a PPP are (1) that no special device is needed to create the pinhole effect and (2) the procedure is surgeon dependent and is effective and can be mastered easily. The option of performing PPP offers a pragmatic solution in cases with higher-order corneal aberrations, offering immense improvement of visual quality. One can also examine the fundus in patients after PPP, as the pupil dilates a little bit if done using the single-pass four-throw pupilloplasty technique.

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Posterior Capsular Rupture in a Toric IOL Patient

David F Chang MD

NOTES

Femto Laser Without Suction

John So-Min Chang MD

Femtosecond LASIK requires femto laser to create the flap. The suction ring used to perform the femto flap formation can sometimes be too large for small Asian eyes. This video will show how to place the suction ring into patients with very small palpebral fissures. Occasionally, suction fails despite repeated attempts. This video will show how to safely perform femto flaps without suction.

LASIK Nightmares

Samir A Melki MD PhD

CASE PRESENTATIONS

- Case 1: Flap Tear
  - Video
  - Mechanism of complication
  - Description of management
  - Result
  - How to avoid this in the future
- Case 2: Femto Suction Loss
  - Video 1: Main pass
  - Video 2: Side cut only
  - Description of management
  - Result
  - Tips to prevent recurrent suction loss: speculum, drops, time
- Case 3: Incomplete Flap
  - Video
  - Management: when to proceed, when to abort
  - Description of causes
  - How to avoid this in the future
- Case 4: Pseudomeniscus (Incomplete Flap 2)
  - Video
  - Mechanism of complication
  - Description of management
  - Result
  - How to avoid this in the future
- Case 5: Central Toxic Keratopathy
  - Serial photographs
  - Review of proposed pathophysiology
  - Description of management
  - Result
- Case 6: Vertical Bubble Breakthrough
  - Video
  - Mechanism of complication
  - Description of management: when to proceed, when to abort

SMILE to Frown

… and Back to Smile Again

Renato Ambrósio Jr MD

I. Introduction

A. Small-incision lenticule extraction (SMILE) has become increasingly popular. While visual and refractive outcomes and safety in terms of the change in distance corrected visual acuity (DCVA) have been shown to be similar to those achieved with LASIK, there are some expected benefits of using the small incision instead of a hinged flap:

1. Less postoperative dry eye after SMILE because the anterior corneal nerves are less affected

2. Lower biomechanical impact with increased biomechanical stability due to the absence of a flap

3. Potential marketing advantage

B. However, there may be a longer learning curve, and different complications may occur. These can be categorized or classified as intraoperative and postoperative complications.

C. Adequate preoperative evaluation and counseling for the patient are fundamental to preventing complications. Advising the patient what to expect during the procedure helps in centration and avoiding suction loss.

D. Strategies for preventing complications should include also a conscious screening with multimodal refractive imaging.

II. Multimodal Refractive Imaging for Screening Refractive Candidates

A. Each refractive surgeon should understand the technologies available and decide which to use for screening, planning, and evaluating results of refractive procedures.

B. It may be useful to apply the "Samurai Strategy" as it relates to understanding what you have available and how to use it to prevent complications: "If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself but not the enemy, for every victory gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle." Sun Tzu, *The Art of War*

C. Review and classification of imaging methods for refractive surgery

1. Corneal geometry and shape

a. Corneal topography: characterization of the front surface of the cornea

b. Corneal pachymetry: assessing corneal thickness, typically with ultrasound from a single point at the center and/or paracentral points

c. Corneal tomography: 3-D corneal characterization, depicting front and back elevation and thickness mapping

d. Segmental or layered corneal tomography: assessing corneal layers

i. epithelial thickness mapping

ii. Bowman layer thickness and regularity

iii. Descemet membrane thickness

iv. air-epithelial curvature

v. epithelial-Bowman curvature

2. Corneal cells

a. Specular microscopy for assessing corneal endothelium

b. Confocal microscopy for assessing epithelial surface and basal cells, corneal nerves, stromal cells, and endothelium of the cornea

3. Ocular surface evaluation

a. Tear film volume

b. Tear film stability

i. breakup time of the tear film

ii. optical degradation time

c. Lipid layer evaluation

d. Dynamics of eyelid blinking and tear film regeneration

e. Bulbar redness

f. Meibomian gland evaluation

g. Other tests: osmolarity, biomarkers for inflammation (MMP9 and others)

4. Corneal biomechanical assessment

5. Optical quality assessment of the eye

a. Ocular wavefront: assessing optical properties and quality of the whole eye, possibly integrating with corneal wavefront for calculating intraocular aberrations (wavefront accommodation testing)

b. Optical scatter index

c. Subjective contrast sensitivity and glare testing

Table 1.

Complication	What We Are Screening for Preoperatively	How to Screen for It
Progressive keratectasia	• Detect mild forms of keratoconus, ectasia susceptibility • Consider refractive treatment and the impact on the cornea	• Placido-disk corneal topography, Scheimpflug tomography, OCT (or VHF US) segmental tomography and biomechanical assessments • Integration with the impact on the cornea by LVC
Tear dysfunction and dry eye	Characterize contact lens intolerance, dry eye preoperatively; poor ocular surface health	Questionnaires, tear film osmolarity and inflammation biomarker, tear film stability and optical regularity, meibomian gland visualization with infrared
Ocular pain/dysesthesia	Assess tear dysfunction syndrome; systemic neuropathy; low vitamin B_{12} or D	• Confocal microscopy • Esthesiometry
Epithelialization of the interface (SMILE and LASIK)	Detect occult corneal basement membrane dystrophy	High-resolution OCT for the evaluation of the epithelial basement membrane and adhesion complex
Severe quality of vision symptoms	Assess preoperative visual performance	Mesopic/scotopic pupil size, corneal/ocular wavefront

Abbreviations: VHF US, very high frequency ultrasound; LVC, laser vision correction.

III. The Focus on Preventing Complications

"There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know." — Donald Rumsfeld

A. The goal is to identify conditions that predispose the patient for specific complications in order to define the most appropriate strategy to optimize such state if possible, and/or to plan the safest and most efficient procedure.

B. Which complications should we consider?

1. Progressive keratectasia
2. Tear dysfunction and dry eye
3. Ocular pain
4. Epithelialization of the interface (SMILE and LASIK)
5. Severe quality of vision symptoms
6. Others: infective keratitis, inflammation

IV. How to Identify Patients at Risk for Each Complication?

See Table 1.

V. Advances in Understanding Progressive Keratectasia

A. Uncommon, but severe complication of laser vision correction (LVC) procedures

B. Ectasia occurs due to a combination of 3 basic factors:

1. Preoperative ectatic corneal disease (the most important risk factor)
2. The surgical impact on corneal structure
3. Postoperative trauma (ie, eye rubbing) or other weakening (ie, pregnancy)

VI. From SMILE to Frown: My First Case of Ectasia after LVC

A 26-year-old female patient presented with mild contact lens intolerance as a candidate for LVC. Uncorrected distance visual acuity (UDVA) was counting fingers in each eye; manifest refraction (MRx): –9.50 –0.50 x 160 OD, giving 20/20, and –9.50 –0.50 x 173 OS, giving 20/20.

The patient underwent uneventful SMILE on October 7, 2014. UDVA was 20/25+ in each eye at postop week 1. One month after SMILE, UDVA was 20/20 in each eye and MRx was pl –0.25 x 63, giving 20/20+ OD, and –0.25 –0.25 x 16, giving 20/20 OS.

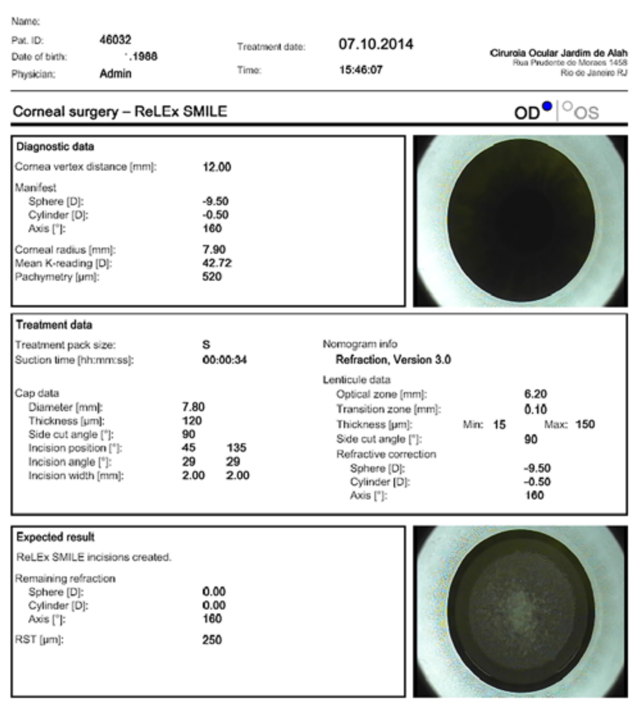

Figure 1. SMILE plan OD.

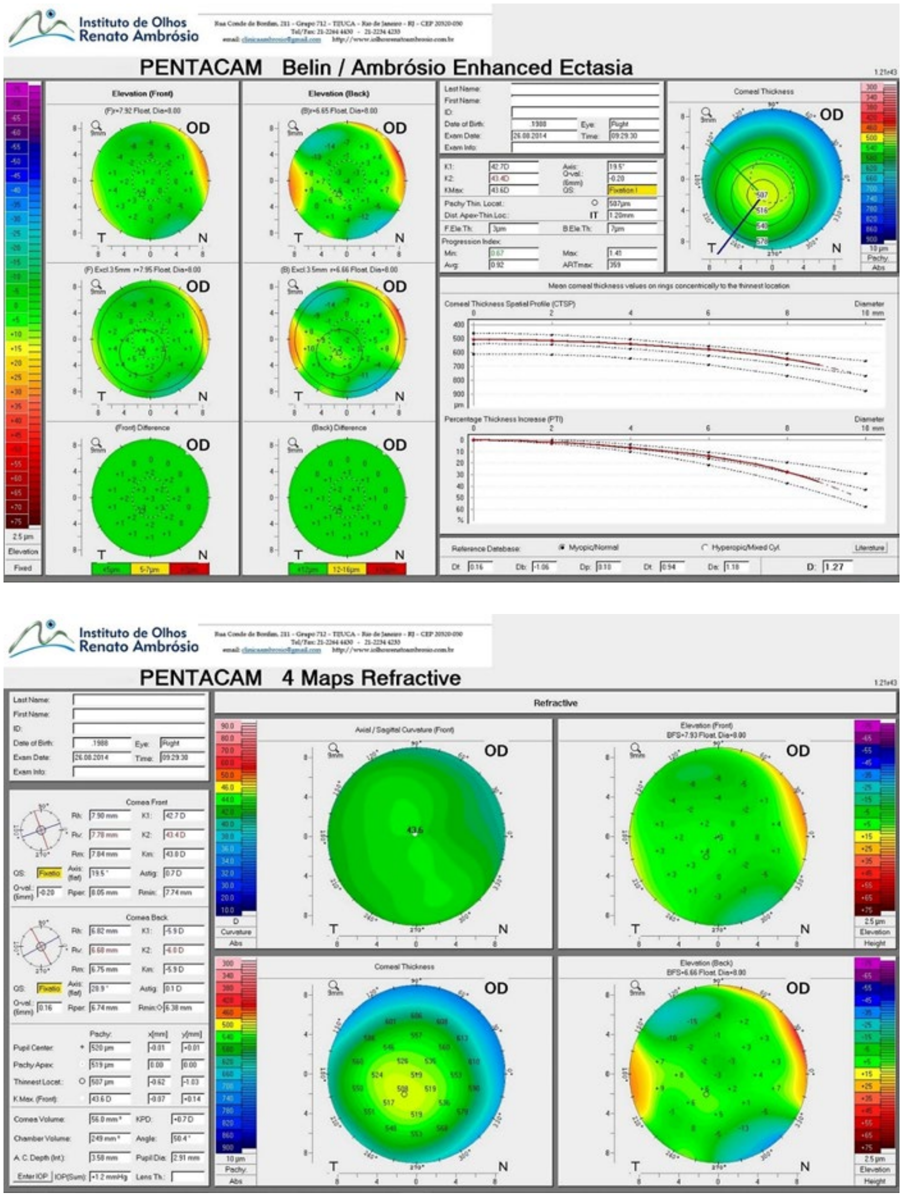

Figure 2. Preop Pentacam OD: normal prolate (Q = −0.28) with low astigmatism on front curvature; normal front and back elevation, 507 µm at thinnest and ARTMax of 359 µm and BAD-Dv3 1.27.

Vision remained stable until 1 year after surgery along with corneal topography.

In November 19, 2018 (4 years after SMILE), the patient returned, complaining of vision decrease in OD. UDVA was 20/100 OD and 20/25 OS; MRx was −2.00 −4.00 x 55 OD, giving 20/25- and pl. −1.00 x 95 OS, giving 20/15. Diagnosis of corneal ectasia OD was confirmed by Placido topography (Oculus Keratograph 5M) and Scheimpflug tomography (Pentacam AXL; Oculus; Wetzlar, Germany).

The patient was counseled about ectasia as a rare and unexpected complication after SMILE. She admitted having rubbed the right eye more intensively over the last year.

Oral nutrition supplementation with omega-3 essential fatty acid (EFAn3) 1 g twice a day and riboflavin (B2) 500 mg once a day were prescribed, along with topical olopatadine 0.2% and preservative-free artificial tears. Advice against eye rubbing was extensively explained, and the patient was scheduled for femtosecond-assisted intracorneal ring segment (FS-ICRS) implantation combined with epi-on crosslinking, injecting dextran-free riboflavin solution inside the tunnel, followed by 10-minute application of UVA with 9 mW/cm^2 (Avedro; Burlington, MA), which was accomplished on December 19, 2018.

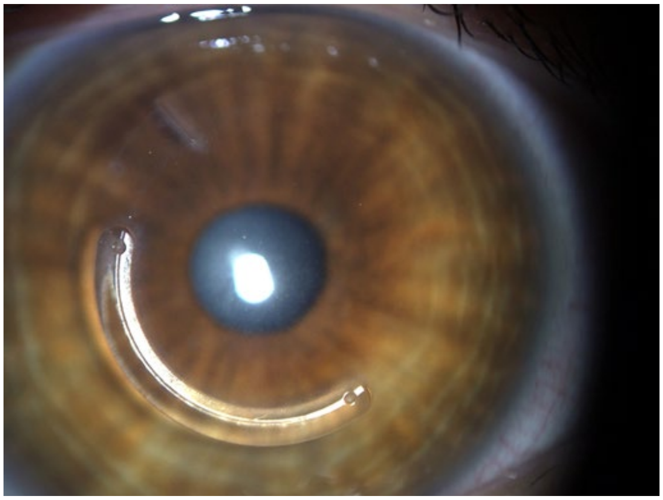

Figure 3. Postop intracorneal ring segment OD.

Six months after FS-ICRS + TE-CXL, the patient was doing well and referred vision improvement. UDVA was 20/25- OD and MRx was –0.50 –0.50 x 2, giving 20/20-.

Retrospective post hoc analysis of the preoperative data (the integrated Scheimpflug tomography and biomechanical assessment [Oculus Corvis ST] and also the segmental tomography, indicating mild thinning of the epithelium) identified moderate susceptibility for ectasia. OS remains stable.

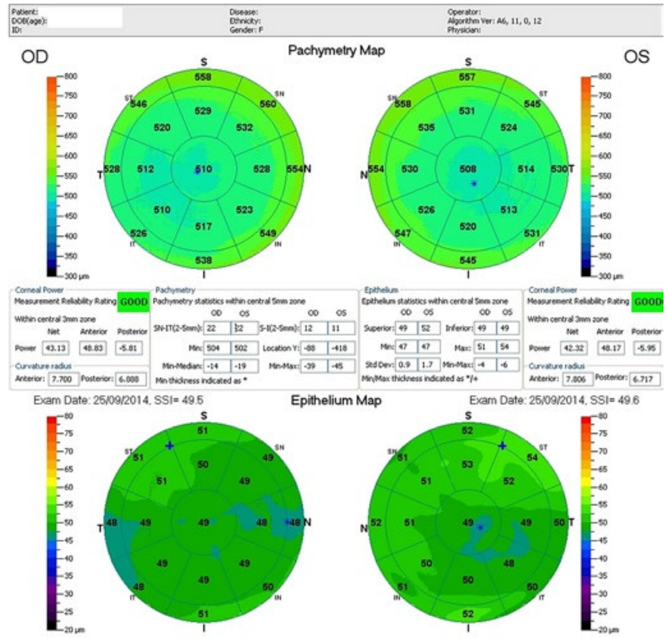

Figure 5. Pre-SMILE OCT.

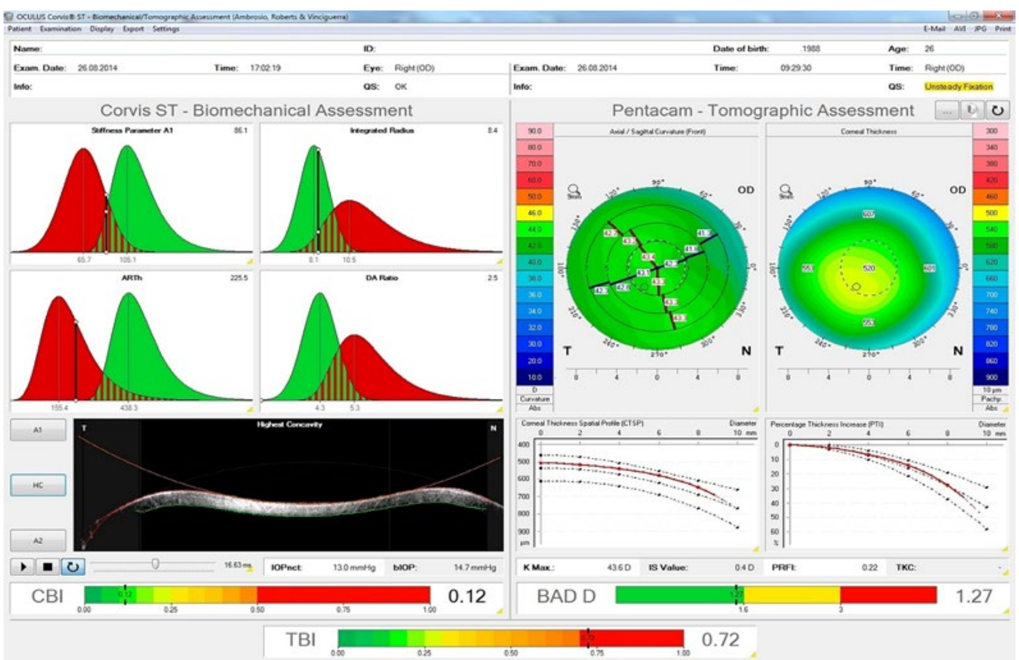

Figure 4. TBI of 0.72, which is abnormal and objectively identifies ectasia susceptibility OD.

The Impact of Photorefractive Keratectomy and Mitomycin C on Corneal Nerves and Their Regeneration

Carla S Medeiros MD, Gustavo K Marino MD, Luciana Lassance PhD, Shanmugapriya Thangavadivel PhD, Marcony R Santhiago MD PhD, and Steven E Wilson MD

Abstract

Purpose

To determine how photorefractive keratectomy (PRK) and mitomycin C (MMC) affect corneal nerves and their regeneration over time after surgery.

Methods

Twenty-eight New Zealand rabbits had corneal epithelial scraping with (n = 3) and without (n = 3) MMC 0.02% or −9.00 diopter PRK with (n = 6) and without (n = 16) MMC 0.02%. Corneas were removed after death, and corneal nerve morphology was evaluated using acetylcholinesterase immunohistochemistry and beta-III tubulin staining after 1 day for all groups, after 1 month for PRK with and without MMC, and 2, 3, and 6 months after PRK without MMC. Image-Pro software (Media Cybernetics; Rockville, MD) was used to quantitate the area of nerve loss after the procedures and, consequently, regeneration of the nerves over time. Opposite eyes were used as controls.

Results

Epithelial scraping with MMC treatment did not show a statistically significant difference in nerve loss compared to epithelial scraping without MMC ($P = .40$). PRK with MMC was significantly different from PRK without MMC at 1 day after surgery ($P = .0009$) but not different at 1 month after surgery ($P = .90$). In the PRK without MMC group, nerves regenerated at 2 months ($P < .0001$) but did not return to the normal preoperative level of innervation until 3 months after surgery ($P = .05$). However, the morphology of the regenerating nerves was abnormal—with more tortuosity and aberrant innervation compared to the preoperative controls—even at 6 months after surgery.

Conclusions

PRK negatively impacts the corneal nerves, but they are partially regenerated by 3 months after surgery in rabbits. Nerve loss after PRK extended peripherally to the excimer laser ablated zone, indicating that there was retrograde degeneration of nerves after PRK. MMC had a small additive toxic effect on the corneal nerves when combined with PRK that was only significant prior to 1 month after surgery.

[*J Refract Surg.* 2018; 34(12):790-798.]

Influence of Microstructure on Stiffening Effects of Corneal Crosslinking Treatment

Hamed Hatami-Marbini PhD

Abstract

Purpose

To investigate the stiffening effects of corneal cross-linking (CXL) on tensile properties of anterior and posterior corneal flaps.

Methods

A Descemet-stripping automated endothelial keratoplasty system was used to prepare anterior and posterior flaps from porcine corneas. The flaps were subjected to CXL, and their mechanical behavior was assessed by conducting uniaxial tensile experiments. Full-thickness corneas were also cross-linked from the posterior and anterior side, and their tensile behavior was measured.

Results

The CXL procedure significantly improved biomechanical properties of anterior flaps ($P < .05$). CXL did not have any significant effect on tensile properties of posterior flaps. Cross-linking full-thickness porcine corneal stroma from the posterior side had no significant stiffening effect.

Conclusions

The stiffening effect of CXL therapy depends significantly on the composition and microstructure of corneal extracellular matrix.

[*J Refract Surg.* 2018; 34(9):622-627.]

Oxygen Diffusion May Limit the Biomechanical Effectiveness of Iontophoresis-Assisted Transepithelial Corneal Crosslinking

Emilio A Torres-Netto MD, Sabine Kling PhD, Nikki Hafezi MASIP ETHZ, Paolo Vinciguerra MD, J Bradley Randleman MD, and Farhad Hafezi MD PhD

Abstract

Purpose

To evaluate the impact of varying treatment time on the efficacy of iontophoresis-assisted transepithelial corneal cross-linking (I-CXL) in ex vivo porcine corneas.

Methods

One hundred twelve porcine corneas with intact epithelium were divided into 7 groups and analyzed. Groups 1, 2, and 3 received standard epithelium-off CXL (S-CXL) with hypo-osmolaric 0.1% riboflavin and 30 minutes of ultraviolet-A (UV-A) irradiation at 3 mW/cm^2, 10 minutes at 9 mW/cm^2, or were not irradiated (controls). Groups 4, 5, 6, and 7 received I-CXL for either 60 minutes at 1.5 mW/cm^2, 30 minutes at 3 mW/cm^2, 10 minutes at 9 mW/cm^2, or were not irradiated (controls). Elastic modulus and stress after relaxation of 5-mm wide corneal strips were analyzed.

Results

In the S-CXL groups, significant differences ($P \leq .05$) in stress-strain extensometry were found between controls and 3 mW/cm^2 for 30 minutes (Group 1) and between controls and 9 mW/cm^2 for 10 minutes (Group 2). In the I-CXL groups, only the 1.5 mW/cm^2 for 60 minutes setting (Group 4) showed a significant stiffening effect. All epithelium-off groups provided a stiffening effect significantly stronger than I-CXL: with a stiffening effect of 149% and 112%, Groups 1 and 4 were the groups with greater elastic modulus between the S-CXL and I-CXL groups, respectively.

Conclusions

The biomechanical effect of I-CXL increased significantly when using a low irradiance/long irradiation setting. Oxygen diffusion thus represents a limiting factor even when riboflavin penetration is improved via iontophoresis. Still less effective than S-CXL, this modification may help establish transepithelial CXL as a treatment option in selected cases.

[*J Refract Surg*. 2018; 34(11):768-774.]

Bilaterally Asymmetric Corneal Ectasia Following SMILE With Asymmetrically Reduced Stromal Molecular Markers

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Abstract

Purpose

To evaluate extracellular matrix regulators and inflammatory factors in a patient who developed ectasia after small-incision lenticule extraction (SMILE) despite normal preoperative tomographic and biomechanical evaluation.

Methods

The SMILE lenticules from both eyes of the patient with ectasia and 3 control patients (5 eyes) matched for age, sex, and duration of follow-up were used for gene expression analysis of lysyl oxidase (LOX), matrix metalloproteinase 9 (MMP9), collagen types I alpha 1 (COLIA1) and IV alpha 1 chain (COLIVA1), transforming growth factor-beta (TGF-beta), bone morphogenetic protein 7 (BMP7), interleukin-6 (IL-6), cathepsin K, cluster of differentiation 68, integrin beta-1, and tissue inhibitor of metalloproteinase-1 (TIMP1). Furthermore, the functional role of LOX was assessed in vitro by studying the collagen gel contraction efficiency of LOX overexpressing in primary human corneal fibroblast cells.

Results

Preoperatively, manifest refraction was –9.25 diopters (D) in the right eye and –10.00 D in the left eye. Corneal thickness, Pentacam (Oculus Optikgeräte GmbH; Wetzlar, Germany) tomography, and Corvis biomechanical indices (Oculus Optikgeräte GmbH) were normal. The ectatic eye lenticule (left) had reduced expression of LOX and COLIA1 compared to controls without ectasia. Increased mRNA fold change expression of TGF-beta, BMP7, IL-6, cathepsin K, and integrin beta-1 was noted in the ectatic left eye compared to controls; however, MMP9 and TIMP1 levels were not altered. Ectopic LOX expression in human corneal fibroblast induced significantly more collagen gel contraction, confirming the role of LOX in strengthening the corneal stroma.

Conclusions

Reduced preexisting LOX and collagen levels may predispose clinically healthy eyes undergoing refractive surgery to ectasia, presumably by corneal stromal weakening via inadequately cross-linked collagen. Preoperative molecular testing may reveal ectasia susceptibility in the absence of tomographic or biomechanical risk factors.

[*J Refract Surg*. 2019; 35(1):6-14.]

Biomechanics of LASIK Flap and SMILE Cap: A Prospective, Clinical Study

Pooja Khamar MD, Rohit Shetty MD PhD FCRS, Ravish Vaishnav MD, Mathew Francis MTech, Rudy MMA Nuijts MD PhD, and Abhijit Sinha Roy PhD

Abstract

Purpose

To analyze the acute effect of flap cut in laser in situ keratomileusis (LASIK) eyes and cap cut in small-incision lenticule extraction (SMILE) eyes on corneal biomechanical properties of patients undergoing surgery.

Methods

This was a prospective, interventional, longitudinal case series. Forty-eight eyes of 24 patients underwent contralateral LASIK and SMILE. Corvis ST (Oculus Optikgeräte GmbH; Wetzlar, Germany) measurements were performed preoperatively, intraoperatively, and 1 week and 1 month after surgery. In LASIK eyes, the flap was cut but not lifted before intraoperative measurements. In SMILE eyes, the cap and side cut incision were made before intraoperative measurement. Thirty biomechanical variables were analyzed, assuming multiple comparisons.

Results

In LASIK and SMILE eyes, 36.7% and 13.3% of the total number of variables detected biomechanical weakening after flap and cap cuts ($P = .02$), respectively. Further, 13.3% and 40% of the total variables detected no biomechanical changes after flap and cap cut, respectively ($P = .03$). These acute biomechanical effects of flap and cap cuts did not influence 1-week and 1-month measurements ($P > .05$) because both LASIK and SMILE eyes showed similar biomechanical weakening.

Conclusions

Flap and cap cuts induced biomechanical weakening in patient corneas. The flap caused more weakening than the cap intraoperatively. However, biomechanical differences between LASIK and SMILE eyes were similar after removal of tissue and ongoing wound healing.

[*J Refract Surg*. 2019; 35(5):324-332.]

CIRCLE Enhancement After Myopic SMILE

Jakob Siedlecki MD

Introduction

In contrast to LASIK, which can be retreated by a flap re-lift, enhancement after small-incision lenticule extraction (SMILE) using a re-SMILE is currently neither approved nor commercially available in the VisuMax platform (Carl Zeiss Meditec AG; Jena, Germany), and only very sparse experimental data on its safety and efficacy exist.[1] Multiple alternative enhancement options have been proposed and established, including surface ablation,[2] cap-to-flap conversion using the CIRCLE program,[3] and thin-flap LASIK.[4] In the following, I want to discuss the advantages and disadvantages of CIRCLE retreatment after SMILE, which converts the SMILE cap into a femtosecond-LASIK flap.

CIRCLE: Surgical Technique

The CIRCLE software is integrated into the VisuMax platform. (However, it is currently not available in the United States.) It has been specifically developed for enhancements and can convert the SMILE cap into a full flap for secondary excimer laser enhancement.[3] Four CIRCLE patterns with different sequential laser cuts for flap conversion are available,[5] of which Riau et al found pattern D the easiest to lift in a study in 12 eyes of 6 New Zealand white rabbits.[5]

For pattern D, the first step is the creation of a lamellar ring around the original cap cut at the same depth as the cap.[5] Secondly, a side cut is created around the new incision plane, with exception of an area used as hinge.[5] Thirdly, a junction cut parallel to the side cut is created to establish a connection between the planes of the primary cap and the secondary lamellar ring around it, creating one large joint plane.[5] Rotation of the flap has to be preprogrammed in such a fashion that the planned new flap hinge area does not overlap with the former side cut incision (eg, SMILE incision at 130° and CIRCLE flap at 50°).

To facilitate surgical manipulation, the outer diameter of the CIRCLE procedure should be programmed to extend beyond the SMILE interface (eg, 8.2 mm over 7.9 mm or larger, depending on the white-to-white diameter).[6] The inner diameter should be smaller than the lenticule (eg, 6.2 mm within 6.5 mm). CIRCLE flaps can be lifted using a blunt spatula like regular LASIK flaps. The postoperative application of mitomycin C is not necessary in routine cases due to the low potential for postoperative haze.[6]

CIRCLE: Clinical Outcomes and Advantages/ Disadvantages

CIRCLE is generally considered to provide outcomes noninferior to those of surface ablation retreatment after SMILE, and noninferior safety and efficacy as compared to LASIK retreatments. In a study on 22 eyes, Siedlecki et al found safety and efficacy indices of 1.03 and 0.97 at 3 months.[3] In another matched study in 24 eyes comparing surface ablation with CIRCLE retreatment, Siedlecki et al found comparable results for both options at 3 months, while CIRCLE retreated eyes showed a markedly quicker visual recovery.[6]

As a disadvantage, CIRCLE sacrifices the idea of a flap-free approach, separating the anterior stroma above the flap from the posterior corneal structures, and thus induces more biomechanical weakening than surface ablation or thin-flap LASIK.[3] This will be especially pronounced in deep caps, eg, >160 µm. In these cases, thin-flap LASIK anteriorly to the SMILE interface might provide better outcomes.

As an advantage, CIRCLE is easy to use and requires less complex preoperative planning than thin-flap LASIK above the SMILE interface.[3] Moreover, its painless nature might be more appealing to many patients than surface ablation, especially in conjunction with the aspect of a quicker visual recovery.

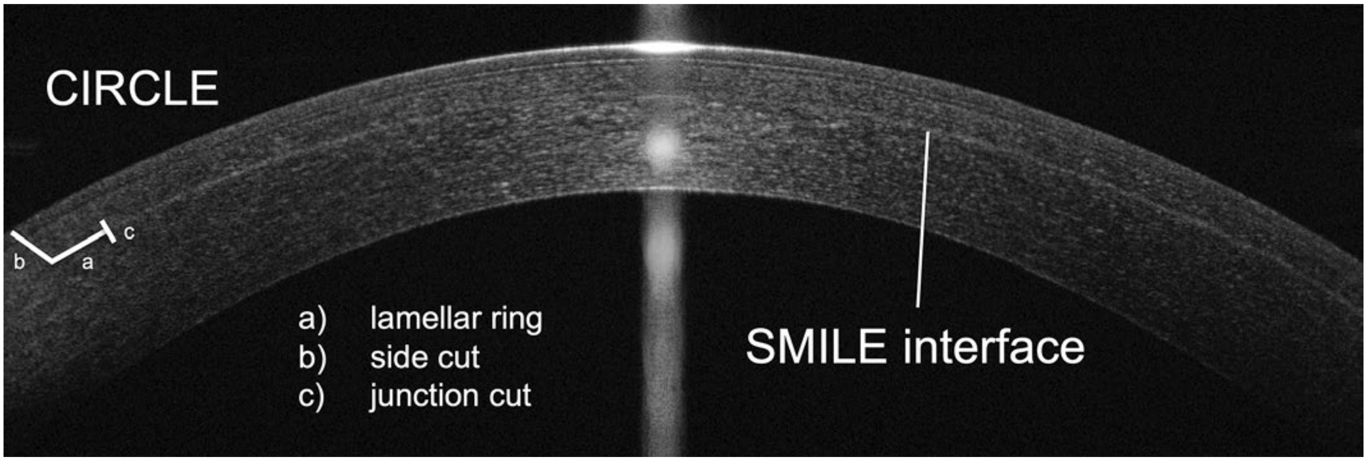

Figure 1. Schematic illustration of SMILE enhancement using CIRCLE. Three laser cuts are performed to generate a lamellar ring around the cap cut (a), a side cut with exception of a hinge area (b) and a vertical junction cut (c) to link both treatment planes.

Conclusion

In conclusion, CIRCLE offers an easy to use, safe, and efficient option for refractive enhancement after SMILE. Thorough preoperative counseling including the advantages and disadvantages compared to surface ablation and thin-flap LASIK enhancement is recommended. From a surgical perspective, cap thickness of the primary SMILE procedure might be the most prominent guiding factor.

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A Comparative Evaluation of a New Generation of Diffractive Trifocal and Extended Depth of Focus Intraocular Lenses

Beatrice Cochener MD PhD, Guillaume Boutillier MD, Mathieu Lamard PhD, and Claire Auberger-Zagnoli MD

Abstract

Purpose

To evaluate and compare the performance of two diffractive trifocal and one extended depth of focus (EDOF) intraocular lenses (IOLs).

Methods

In this 6-month, single-center, prospective, randomized, comparative study, patients undergoing routine cataract surgery were randomized to receive one of two trifocal IOLs (AcrySof IQ PanOptix, Alcon Laboratories, Inc., Fort Worth, TX, or FineVision Micro F; PhysIOL SA, Liège, Belgium) or an EDOF IOL (Tecnis Symfony, Abbott Medical Optics, Inc., Abbott Park, IL). There were 20 patients in each group. The primary outcome was binocular and monocular uncorrected distance (UDVA), intermediate (UIVA), and near (UNVA) visual acuity. The secondary outcomes were quality of vision and aberrometry.

Results

There was no statistically significant difference between groups in either monocular ($P = .717$) or binocular ($P = .837$) UDVA. Monocular and binocular UNVA were statistically and significantly better for both trifocal lenses than for the EDOF IOL ($P = .002$). The percentage of patients with J2 UNVA was 52.5% monocularly and 70% binocularly for the Tecnis Symfony IOL, 81.5% monocularly and 100% binocularly for the AcrySof IQ PanOptix IOL, and 82.5% monocularly and 95% binocularly for the FineVision Micro F IOL. There was no significant difference in binocular UIVA between groups; VA was better than 0.6 in 55%, 53%, and 35% of patients with the Tecnis Symfony, AcrySof IQ Pan-Optix, and FineVision Micro F IOLs, respectively. Overall, 90% patients achieved spectacle independence. There were no differences in visual symptoms and aberrometry among groups.

Conclusions

All three IOLs provided good visual acuity at all distances, a high percentage of spectacle independence, and little or no impact of visual symptoms on the patients' daily functioning. Near vision was statistically better for both trifocal IOLs compared to the EDOF IOL.

[*J Refract Surg.* 2018; 34(8):507-514.]

Reprinted with permission from SLACK Incorporated. Cochener B, Boutillier G, Lamard M, Auberger-Zagnoli C. A comparative evaluation of a new generation of diffractive trifocal and extended depth of focus intraocular lenses. *J Refract Surg.* 2018; 34: 507-514.

Dissatisfaction After Trifocal IOL Implantation and Its Improvement by Selective Wavefront-Guided LASIK

Theo G Seiler MD, Aharon Wegner MD, Tim Senfft MD, and Theo Seiler MD PhD

Abstract

Purpose

To evaluate a substantially improved wavefront acquisition technique (Peramis; Schwind eye-tech-solutions; Kleinostheim, Germany) for selective wavefront-guided aberration correction to improve satisfaction after implantation of trifocal intraocular lenses (IOLs).

Methods

Of 213 eyes from 108 consecutive patients receiving cataract surgery with multifocal IOL implantation (FineVision; PhysIOL; Liége, Belgium), 56 eyes (26%) of 42 dissatisfied patients were treated with selective wavefront-guided laser in situ keratomileusis (LASIK) (Amaris 1050; Schwind eye-tech-solutions) free of cost with a follow-up of 12 months. Selective wavefront-guided ablation corrected for all aberrations except spherical aberrations to preserve the apodization and therefore to enhance the multifocal effect. The degree of satisfaction after trifocal IOL implantation, its increase after selective wavefront-guided LASIK, and the refractive error (spherical equivalent, refractive astigmatism) before and after selective wavefront-guided LASIK were evaluated.

Results

Refractive astigmatism of greater than 0.50 diopters (D) was the most frequent residual refractive error (63%), followed by myopia (45%), hyperopia (20%), and increased ocular higher-order aberrations (13%). After selective wavefront-guided LASIK, the refractive target (±0.50 D) was achieved in 98% and refractive astigmatism was 0.50 D or less in 93% of the eyes operated on. The overall satisfaction score in dissatisfied patients increased from 2.1 ± 0.8 preoperatively to 3.6 ± 0.8 (out of 4). Eighty-eight percent of initially dissatisfied patients would choose this procedure again.

Conclusions

Selective wavefront-guided LASIK reduced refractive errors and significantly increased spectacle independence and satisfaction, which may lead to a better acceptance of trifocal IOLs.

[*J Refract Surg*. 2019; 35(6):346-352.]

Primary Topography-Guided LASIK: Treating Manifest Refractive Astigmatism Versus Topography-Measured Anterior Corneal Astigmatism

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Originally published in Journal of Refractive Surgery, *2019; 35(1):15-23, doi: 10.3928/1081597X-20181113-01.*

Abstract

Purpose

To investigate whether topography-guided laser in situ keratomileusis (LASIK) with anterior corneal astigmatism measured on the WaveLight Contoura (Alcon Laboratories, Inc.; Fort Worth, TX) leads to better refractive outcomes compared to treating on the clinically measured manifest refractive astigmatism axis in eyes with primary myopic astigmatism.

Methods

Retrospective analysis of 1,274 consecutive LASIK eyes treated on the topography-measured anterior corneal astigmatism axis compared to eyes treated on the conventional clinical manifest refractive astigmatism axis.

Results

In eyes with a small axis discrepancy between anterior corneal astigmatism and refractive astigmatism of 5° to 20°, there was no significant difference in efficacy index, refractive astigmatism accuracy, and most Alpins vector analysis parameters. Both treatment modalities achieved 20/20 uncorrected distance visual acuity (UDVA) in 90% of eyes, with 95% having postoperative cylinder of 0.50 diopters (D) or less. In eyes with a large axis discrepancy between 21° and 45° treated on the anterior corneal astigmatism axis, outcomes were both statistically and clinically inferior. Fewer eyes achieved UDVA of 20/20 (88.9% vs. 73.6%; $P = .01$), and fewer had a defocus equivalent of 0.25 (65.6% vs. 52.7%), 0.50 (86.9% vs. 80.0%), and 0.75 (97.5% vs. 90.9%) D or less ($P < .05$ for all). Significantly more eyes achieved an angle of error greater than 15° (25.4% vs. 8.1%; $P = .004$), had postoperative residual astigmatism of 0.75 D or less (18.2% vs. 7.4%; $P = .03$), and needed an excimer laser retreatment (11% vs. 1.6%; $P = .007$).

Conclusions

Topography-guided myopic astigmatism LASIK treated on the topography-measured anterior corneal astigmatism axis resulted in inferior refractive and visual outcomes compared to treating on the clinical manifest refractive astigmatism axis.

[*J Refract Surg*. 2019; 35(1):15-23.]

Are You AT the Table or ON the Menu?

Stephanie J Marioneaux MD

Ophthalmology's goal to protect sight and empower lives requires active participation and commitment to advocacy from every ophthalmologist. Contributions to the following three critical funds are a part of that commitment:

- OPHTHPAC®
- Surgical Scope Fund (SSF)
- State Eye PAC

Please join the dedicated community of ophthalmologists who are contributing to protect quality patient eye care for everybody.

The OPHTHPAC Committee is identifying Congressional Advocates in each state to maintain close relationships with federal legislators to advance ophthalmology and patient causes. At Mid-Year Forum 2019, we honored three of those legislators with the Academy's Visionary Award. This served to recognize them for addressing issues important to us and to our patients. The Academy's Secretariat for State Affairs is collaborating closely with state ophthalmology society leaders to protect Surgery by Surgeons at the state level.

Our mission of "protecting sight and empowering lives" requires robust funding of both the Surgical Scope Fund and OPHTHPAC. Each of us has a responsibility to ensure that these funds are strong so that ophthalmology can be represented "at the table."

OPHTHPAC®

OPHTHPAC represents the profession of ophthalmology to the U.S. Congress and operates to protect you and your fellow ophthalmologists from payment cuts, burdensome regulations, scope-of-practice threats, and much more. OPHTHPAC also works to advance our profession by promoting funding for vision research and expanded inclusion of vision in public and private programs—all of which provide better health-care options for your patients. OPHTHPAC is your federal voice in Washington, D.C., and we are very successful in representing your professional needs to the U.S. Congress.

Among OPHTHPAC's most recent victories are the following:

- Securing greater flexibility in the new Medicare Payment System
- Ensuring proper reimbursement of Medicare Part B drugs
- Blocking onerous administrative burdens on contact lens prescribers
- Preserving access to compounded drugs
- Preventing additional cuts to Medicare

However, ophthalmology's federal issues are a continuous battle, and OPHTHPAC is always under pressure to ensure we have strong political connections in place to help protect ophthalmology, its members, and their patients.

The support OPHTHPAC receives from invested U.S. Academy members helps build the federal relationships that advance ophthalmology's agenda on Capitol Hill. These relationships allow us to have a seat at the table with legislators willing to work on issues important to us and our patients. We also use these congressional relationships to help shape the rules and regulations being developed by federal agencies. Help strengthen these bonds and ophthalmology's legislative support.

Right now, major transformations are taking place in health care. To ensure that our federal fight and our PAC remain strong, we need the support of every ophthalmologist to better our profession and ensure quality eye care for our patients. Invest with confidence in the strongest PAC working to ensure your success as an ophthalmologist.

Contributions to OPHTHPAC can be made here at AAO 2019, online at www.aao.org/ophthpac, or by texting MDEYE to 41444.

At Mid-Year Forum 2019, the Academy and the American Society of Refractive & Cataract Surgery (ASCRS) ensured a strong presence of refractive and cataract surgeons to support ophthalmology's priorities. Ophthalmologists visited members of Congress and their key health staff to discuss ophthalmology priorities as part of Congressional Advocacy Day. The ASCRS remains a crucial partner with the Academy in its ongoing federal and state advocacy initiatives.

Surgical Scope Fund

The Surgical Scope Fund (SSF) provides grants to state ophthalmology societies to support their efforts to protect patient safety from dangerous optometric surgery proposals. Since its inception, the Surgery by Surgeons campaign and the SSF, in partnership with state ophthalmology societies, have helped 40 state/territorial ophthalmology societies reject optometric scope-of-practice expansions into surgery.

Thanks to the 2019 SSF contributions from ophthalmologists just like you, SSF has had a successful year, preserving patient safety and surgical standards in state legislatures across the country, including six critical wins in Alabama, Texas, Vermont, Wyoming, Maryland, and Iowa. The 2019 battle is far from over, though. For example, Pennsylvania and Massachusetts are under attack, and California and Illinois are facing threats.

If you have not yet made a 2019 SSF contribution, *contributions can be made at our booth at AAO 2019 or online at www.aao.org/ssf.* If you already have made that 2019 contribution, please go to www.safesurgerycoalition.org to see the impact of your gift.

Dollars from the SSF are critical to building complete cutting-edge political campaigns, including media (TV, radio, and social media), educating and building relationships with legislators, and educating the voting public to contact their legislators. This work helps to secure success in protecting patient safety by defeating optometry's surgical initiatives.

Each of these endeavors is very expensive, and no one state has the critical resources to fight big optometry on their own. Ophthalmologists must join together and donate to the SSF at www.aao.org/ssf to fight for patient safety.

Surgical Scope Fund	OPHTHPAC® Fund	State EyePAC
To protect patient safety by defeating optometric scope-of-practice initiatives that threaten patient safety and quality surgical care	Ophthalmology's interests at the federal level Support for candidates for U.S. Congress	Support for candidates for state House, Senate, and governor
Political grassroots activities, government relations, PR and media campaigns *No* funds may be used for campaign contributions or PACs.	Campaign contributions, legislative education	Campaign contributions, legislative education
Contributions: Unlimited Individual, practice, and organization	Contributions: Limited to $5,000	Contribution limits vary based on state regulations.
Contributions are *100% confidential.*	Contributions above $200 are on the public record.	Contributions are on the public record depending upon state statutes.

The Secretariat for State Affairs thanks the ASCRS, which in the past has joined state ophthalmology societies in contributing to the SSF, and it looks forward to the society's 2019 contribution. These ophthalmic organizations complete the necessary SSF support structure for the protection of our patients' sight.

State Eye PAC

It is increasingly important for all ophthalmologists to support their respective State Eye PACs because campaign contributions to legislators at the state level must come from individual ophthalmologists and cannot come from the Academy, OPHTHPAC, or the SSF. The presence of a strong State Eye PAC providing financial support for campaign contributions and legislative education to elect ophthalmology-friendly candidates to the state legislature is critical, as scope-of-practice battles and many regulatory issues are all fought on the state level.

ACTION REQUESTED: Help Ophthalmology Ensure a "Seat at the Table"

Academy SSF contributions are used to support the infrastructure necessary for state legislative/regulatory battles and for public education. State PAC and OPHTHPAC contributions are necessary at the state and federal levels, respectively, to help elect officials who will support the interests of our patients. Contributions to *each* of these three funds are necessary and help us protect sight and empower lives. SSF contributions are completely confidential and may be made with corporate checks or credit cards, unlike PAC contributions, which must be made by individuals and are subject to reporting requirements.

Please respond to your Academy colleagues and be part of the community that contributes to OPHTHPAC, the SSF, and your State Eye PAC. Please be part of the community that ensures ophthalmology has a strong voice in advocating for patients.

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ESCRS Symposium: What Happened to Our Patient in the Long Term

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iDrops: C,O
Ivantis: C,O
Johnson & Johnson Vision: C
Mynosys: C,O
Perfect Vision: C
PowerVision, Inc.: C,O
Presbyopia Therapies: O
RX Sight: C,O
SLACK, Incorporated: P
Surface, Inc.: O
Versant Ventures: O
Viewpoint: C,O

John So-Min Chang MD
Alcon Laboratories, Inc.: L
Carl Zeiss, Inc.: L
Hongkong Global Vision Ltd.: S,L
Johnson & Johnson: L

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Alcon Laboratories, Inc.: C,S
Horus: C
Hoya: C
Johnson & Johnson: C
Santen, Inc.: C
THEA: C
Zeiss: C

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None

Arthur B Cummings MD
Alcon Laboratories, Inc.: C,L
CSO: C,L
KeraNova: C
Merck & Co., Inc.: C
Oculis: C
Shire: C
TearLab Corp.: C
Vivior: C
WaveLight AG: C,L

Sheraz M Daya MD
Allergan, Inc.: L
Bausch + Lomb: C,L,S
Carl Zeiss Meditec: C
Ellex: L
Excellens: C,O
Johnson & Johnson Vision: S
Lumenis Vision: C
Medicem: C
Nidek: C
Omeros Corp.: C
PhysIOL: L
PRN Physician Recommended Nutriceuticals: C,O
Scope Pharmaceuticals Ltd: C
Staar Surgical: C
Strathspey Crown: O
TearLab Corp.: C

Deepinder K Dhaliwal MD
Avedro, Inc.: S
CorneaGen: L
Johnson & Johnson: C
Novaliq: C
Noveome: S
Ocular Therapeutix: L
Shire: S,L
Staar Surgical: L

Burkhard Dick MD
Allergan, Inc.: L
Avedro, Inc.: C
Bausch + Lomb: L
Carl Zeiss Meditec: C
Johnson & Johnson Vision: C
Johnson & Johnson: L
Oculus Surgical, Inc.: P
Oculus, Inc.: L
Optical Express AG: C
Polytech-Domilens GmbH: C
RxSight, Inc.: C

Eric D Donnenfeld MD
Alcon Laboratories, Inc.: C
Allergan: C,L
Bausch + Lomb: C
Beaver-Visitec International, Inc.: C
Eyepoint Pharma: C
Glaukos Corp.: C
Ivantis: C
Johnson & Johnson: C
LacriScience, LLC: C,O
Mynosis: C,O
PRN Physician Recommended Nutriceuticals: C,O
TLC Laser Center: C
Zeiss: C

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Alcon Laboratories, Inc.: C
Avedro: C
Cleveland Clinic Innovations: P
National Eye Institute: S

Daniel S Durrie MD
AcuFocus, Inc.: C,O
Alcon Laboratories, Inc.: C
Alphaeon: O
Avedro: C,L,O
Concierge Key Health: O,C
Eyegate Pharma: C
Hoopes Durrie Rivera Research Center: C
iOR Holdings: O
iOR Partners: O
Johnson & Johnson Vision: C,L
Strathspey Crown LLC: O

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Alcon Laboratories, Inc.: C
Carl Zeiss: C
Johnson and Johnson: C
Merck: C

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Bausch + Lomb: C
Johnson & Johnson: C
Thieme Medical Publishers: P

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Nidek, Inc.: C,L
PhysIOL: P
WaveLight AG: C

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None

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Abbott Medical Optics: C
AcuFocus, Inc.: C,O
Alcon Laboratories, Inc.: C
ArcScan: C,O
Carl Zeiss, Inc.: C
M & S Technology: C
Oculus, Inc.: C
RxSight, Inc.: C,O
Visiometrics: C,O

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Optovue, Inc.: O,P,S

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None

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ARC Laser GmbH: C
Alcon Laboratories, Inc.: C
Avedro: C
Carl Zeiss Meditec: C
KeraMed, Inc.: C

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None

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None

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Aerie Pharmaceuticals: C
Alcon/Novartis: C
Allergan/Actavis: C
Avedro: C
Avellino Labs: C,O
B+L/Valeant: C
Blephex: C
CorneaGen: C,O
Dompe: C
Eyenovia: C,O
Johnson & Johnson Vision: C
Kala Pharmaceuticals: C,O
NovaBay Pharmaceuticals: C,O
Ocular Therapeutix: C,O
Omeros: C,O
Presbyopia Therapies: C,O
Shire: C
Simple Contacts: C,O
Zeiss: C

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Nidek, Inc.: C
NTK Enterprises: C
Oculus, Inc.: C
Smart EyeDeas I, LLC: C

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Alcon Laboratories, Inc.: C
CAPSULaser: O
Carl Zeiss Meditec: C
Ivantis: O
Johnson & Johnson: C
Perfect Lens: C
Vivior: O

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Carl Zeiss Meditec: C,S
Geuder: C
Hoya: S
Johnson & Johnson Vision (Abbott): C,S
Novartis (Alcon): C,S
Oculentis: C,S
Oculus Optikgeräte: C,S
Santen, Inc.: C
SCHWIND eye-tech-solutions: C,S
STAAR Surgical: C
TearLab Corp.: C
Thea Pharma: C
Thieme Compliance: C
Ziemer: C

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Alcon Laboratories, Inc.: C
Calhoun Vision, Inc.: O
Johnson & Johnson Vision: C
Optoquest: C
Presbia: C
Strathespey Crown: O

Disclosures current as of 9/6/19. Check the Mobile Meeting Guide for the most up-to-date financial disclosures.

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Abbott Medical Optics, Inc.: C
Aerie Pharmaceuticals, Inc.: L
Allergan: C
Eyepoint Pharmaceuticals: C
EyeVance: C
ImprimisRx: C
Kala Pharmaceuticals: L
Novabay: L
Shire: C,L
Sight Sciences: S
Sun Ophthalmics: C,L

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None

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Bio-Tissue, Inc.: C
BlephEx: C
Focus Labs: C
Johnson & Johnson Vision: C
Oculus, Inc.: C
Shire: C

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Allergan: C
Bausch + Lomb: C
Carl Zeiss, Inc.: C
Interactive Medical Publishing: O
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Johnson & Johnson Vision: L
Stroma: O
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Bausch + Lomb: S
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Johnson & Johnson: S
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Johnson & Johnson: S
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Carl Zeiss Meditec: L
Novartis Pharma AG: L

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Ziemer, Inc.: C

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Intelon, Inc.: C,O
Oculentis AG: C,P
Staar Surgical: C

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AcuFocus, Inc.: C,L,O
Alcon Laboratories, Inc.: C,L
Allergan: C
Allotex: C
Bausch + Lomb: C
BRIM Biotechnology, Inc.: C
CSO Srl: C
Carl Zeiss, Inc.: C
Equinox: C,O
Euclid Systems: C
eyeBrain Medical, Inc.: C,O
Eyedetec: C
Eyegate Pharma: C
Healthe: C
Imprimis: C
Johnson & Johnson Vision: C
Mynosys: C,O
Novaliq: C
Ophtec: C
ORA: C
Oyster Point Phama: C
Precision Lens: C
RxSight: C
Sight Sciences, Inc.: C
Stuart Therapeutics: C
Tarsus Rx: C
TearClear: C
ThruFocus: C
Treehouse Health: C,O
Veracity: C
Visant: C
Visiometrics, SL: C
Vivior AG: C

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Alcon Laboratories, Inc.: C
Allergan, Inc.: C,L,S
Alphaeon: O
ArcSCan: O
Avedro: C,L,O
Bausch + Lomb: C,L
CXLO: C,O
CXLUSA: C
EyeVance: C
Guardian Health: C,O
Healthe: O
Iantech: C,O
Kala: C,L
LensAR: C
Oculus, Inc.: L
Shire: C,L
Sun: C,L
True Vision: C,O
Vmax Vision: C

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Nidek: C
Oculus, Inc.: C
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Johnson & Johnson: C
Staar Surgical: C

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None

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Alcon Laboratories, Inc.: C,L
Allergan: C,L
Avedro: C,L
Bausch + Lomb: C,L
GlassesOff: C
Glaukos Corp.: C,L
Ivantis: C
Johnson & Johnson Vision: C,L
Oculus, Inc.: C,L
Omega Ophthalmics: C
Omeros: C
Perfect Lens, LLC: C
Refocus Group, Inc.: C
Riechert: C
SRD Vision: C
Strasthpey Crown: O
Visiometrics: C,O

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Angion Biomedica Corp: C,S
Cambium Medical Technologies: C

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Avellino Labs: S
Carl Zeiss Meditec: C
Resolve Ophthalmics: O,P
Senju Pharmaceutical Co.,Ltd.: S

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Presenter Index

* Indicates that the presenter has financial interest. No asterisk indicates that the presenter has no financial interest.

Refractive Surgery ePosters

Refractive Surgery ePosters

South Exhibition Level, S Esplanade Ballroom Lobby, West, Level 2, Lobby

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Refractive Surgery ePosters

Friday–Tuesday, October 11–15

South Esplanade Ballroom Lobby

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Corneal Laser Vision Correction

Intraocular Refractive Surgery

JRS—Hot, Hotter, Hottest Late Breaking News

Updates in Refractive Surgery

E-poster Abstracts

Corneal Laser Vision Correction

Supervision After Myopic Advanced Surface Ablation: A Myth?
RP30061783

Senior Author: Fabrizio I Camesasca MD
Coauthors: Paolo Vinciguerra MD and Riccardo Vinciguerra MD

Purpose: To study myopic eyes achieving uncorrected distance visual acuity (UCDVA) above 0.1 logMAR after advanced surface ablation (ASA). **Methods:** Retrospective trial of myopic eyes receiving 1050-Hz excimer laser transepithelial ASA. **Results:** Out of 40 myopic treated eyes, 16 eyes of 16 patients (40%) attained UCDVA of 0.10 ± 0.77 logMAR at 6 months. Preoperative BSCVA was 0.05 ± 0.91 logMAR, with a mean SE of 5.43 D ± 2.64 D (range: from 1.63 D to 10.75 D). Mean optical and transition zone diameter (mm) were, respectively, 7.58 ± 0.42 and 1.87 ± 0.53. Coma and trefoil improved significantly. **Conclusion:** UCDVA above 0.1 logMAR after ASA can be attained, also in highly myopic eyes.

Randomized Controlled Trial Comparing Dry Eye After SMILE vs. LASIK
RP30061800

Senior Author: Yu-Chi Liu MD
Coauthors: Angel Jung Se Ji, Marcus Ang MBBS PhD, and Jodhbir S Mehta MBBS PhD

Purpose: To compare dry eye diseases after SMILE vs. LASIK. **Methods:** In this paired-eye study, 70 patients were randomly treated with SMILE and LASIK in each eye. Evaluation of dry eyes was performed at 1 week and 1, 3, 6, and 12 months postoperatively. **Results:** SMILE had significantly more favorable tear break-up time (TBUT) than LASIK at 1 week, 1 and 3 months (all $P < .05$). The TBUT returned to the preoperative level at 6 months in SMILE eyes, while it was still impaired at 12 months in LASIK eyes. SMILE eyes had significantly better Oxford scores in corneal staining than LASIK eyes at 1 week and 1 month, and the staining score recovered to the preoperative level after 6 months postoperatively in both groups. There was no significant difference in the results of Schirmer tests at all time points. **Conclusion:** SMILE has less postoperative negative impacts and faster recovery on ocular surface, compared to LASIK. The difference was not significant after postoperative 3 months.

Changes in Corneal Deformation Evaluated Both With ORA and Corvis ST After Myopic PRK
RP30061805

Senior Author: Michele Lanza MD
Coauthors: Valerio Piccirillo MD, Carlo Irregolare MD, Antonello Iovine MD, Antonio Sorgente, Francesco Sorgente MD, and Raffaele Piscopo MD

Purpose: To evaluate the modifications induced by myopic PRK on corneal biomechanical properties. **Methods:** One eye of 145 patients underwent myopic PRK for a mean refractive defect of −4.69 ± 2.07 D (range from −0.50 D to −10.50 D). A complete eye visit with biomechanical evaluation with both Ocular Response Analyzer (ORA) and Corvis ST (CST) was performed before and after surgery at 1, 3, and 6 months follow-up. **Results:** Corneal hysteresis (CH) and corneal resistance factor (CRF) provided by ORA showed significant decrease after 6 months. Only radius of highest concavity (RHC), among the parameters provided by CST, did not show significant changes after surgery. Differences appeared significantly ($P < .01$) lower at 1 month follow-up, whereas they increased at 6 months follow-up. **Conclusion:** According to these data, myopic PRK produces a corneal modification in elasticity and deformability that is not stable after 1 month, but it is continuing in the following months.

Long-term Visual and Refractive Stability and Ocular Biometric Changes After Customized LASEK for Correction of Myopia (8-Year Follow-up)
RP30061807

Senior Author: Seyed Javad Hashemian MD

Purpose: To assess the long-term visual and refractive stability and ocular biometric changes in low to moderate myopic subjects treated by customized LASEK. **Methods:** Seventy eyes of 35 patients with myopia <6.0 D were included. Uncorrected (UCVA) and distance-corrected visual acuity (DCVA) refractive outcomes and ocular biometric changes by Lenstar LS900 were evaluated preoperatively and 8 years after the operation. **Results:** The mean preoperative SE was −3.99 D, which improved to 0.01 and −0.11 D 6 months and 8 years postop, respectively. The mean cylinder was −0.75, which improved to −0.19 and −0.22 D, respectively. At 6 months and 8 years, logMAR UCVA and CDVA was 0.001, 0.000, 0.024, and 0.002. Keratometry and pachymetry decreased significantly after surgery but was stable during the study. Axial length wasn't changed significantly. **Conclusion:** The long-term visual and refractive outcomes of customized LASEK for correction of low to moderate myopia is safe, stable, and predictable, although ocular biometric changes occurred.

Post-Refractive Topography Prediction Analysis by Trainees
RP30061813

Senior Author: Ravi Shah MD
Coauthor: J Bradley Randleman MD

Purpose: To determine prediction accuracy of patient refractive surgery status based on topography pattern analysis for different anterior curvature maps. **Methods:** Image review by novice reviewers (residents and cornea fellows, n = 20) at a single academic institution. Participants were shown a single image at a time and masked to the map type (axial vs. tangential). Response choices were post-hyperopic, post-myopic, or no prior ablation. **Results:** Accuracy of prediction was 79.6% for tangential vs. 56.7% for axial maps for post-myopic ablation (P = .04), 88.3% for tangential vs. 60.4% for axial maps for post-hyperopic ablation (P = .006), and 23.3% for tangential vs. 60.8% for axial maps for the no ablation group (P = .008). **Conclusion:** Using tangential maps yielded significantly better prediction accuracy compared to axial maps after refractive surgery for novice reviewers. This will benefit post-LASIK IOL calculation accuracy.

Comparison of IOP Measurements Before and After Myopic PRK With Contact and No-Contact Devices
RP30061815

Senior Author: Michele Lanza MD
Coauthors: Valerio Piccirillo MD PhD, Carlo Irregolare MD, Antonello Iovine MD, Antonio Sorgente, Francesco Sorgente MD, and Raffaele Piscopo PhD

Purpose: To evaluate IOP before and after myopic PRK with Goldmann applanation tonometry (GAT), dynamic contour tonometry (DCT), Ocular Response Analyzer (ORA), Corvis ST (CST), and Icare (IC). **Methods:** A complete eye visit, corneal tomography, and IOP evaluation with GAT, DCT, ORA, CST, and IC were performed in 97 eyes of 97 patients before myopic PRK and at 1, 3, and 6 months follow-up. Analysis of IOP differences before and after surgery were run for all devices, and correlations with morphological parameters were studied. **Results:** After PRK, IOP was significantly (P < .05) underestimated with every tonometer tested; at 6 months follow-up, IOP difference between GAT and IC was not significant. **Conclusions:** Even if these results have to be confirmed in further studies, these data suggest that IC and GAT could be interchangeably used to evaluate IOP after myopic PRK.

Double Pass Image Curvilinearity Is Elevated in Topographically Normal Fellow Eyes of Asymmetric Keratoconics
RP30061817

Senior Author: Anthony P Leonard MD
Coauthors: Kevin Garza MD, Caleb Morris MD, Mujtaba A Qazi MD, Jay Stuart Pepose MD PhD, and Andrew J W Huang MD MPH

Purpose: To detect eyes at risk for keratoconus (KC) or postoperative ectasia. **Methods:** Cross-sectional, noninterventional study. IRB approved by Washington University. Double pass (DP) images obtained using a commercially available instrument (HD Analyzer, Visometrics, SA) were analyzed using FIJI. Topography was performed by Placido disc (Zeiss). Kruskal-Wallis tests with Dunn's correction for multiple comparisons and receiver-operating characteristic analysis were computed using GraphPad Prism 6. **Results:** Compared to normal eyes, curvilinearity was increased in KC as well as in the topographically normal fellow eyes of patients with asymmetric KC ("form fruste KC," FFKC) (P < .005, n = 6, 8, 4). Area under the receiver operating characteristic curve was 0.979 (normal vs. KC) and 1.00 (normal vs. FFKC). **Conclusion:** Double pass image analysis reliably discerns normal eyes from KC eyes, including those with a normal topographic appearance.

Comparative Analysis of Visual Quality of Low and Mid-Grade Myopia Treated by SMILE and TransPRK
RP30061822

Senior Author: Xiaoli Wang MD
Coauthors: Yingping Deng and Fangrong Cai

Purpose: To evaluate and comparatively analyze the visual quality of myopic patients after SMILE and TransPRK. **Methods:** A prospective case-control study. Sixty-nine patients (138 eyes) were allocated into SMILE group (S; 94 eyes)and TransPRK group (T; 44 eyes). Pre-SE of the patients were –1.00 D to –6.00 D. The subjects were measured preop and 1 week, 1 month, and 3 months postop, with measurements including uncorrected distance visual acuity (UDVA), best-corrected distance VA, SE, CS, MTF, SR, and the QIRC. **Results:** Both the groups had the better postoperative UDCA; the SE of the S group was lower than the T group. At 3-mm aperture, the HOAs and the SE of the S group were lower than those of the T group. The total aberration of the SMILE group was lower than the T group. The total MTF of the S group was better than the T group, and same to the total SR. CS: 3 cpd of the S group was lower than the T group. 12 cpd and 18 cpd of the S group were higher than those of the T group. The post-CS in the 2 groups were higher than the preoperative. QIRC: All the scores of two groups post were higher than pre. **Conclusion:** The S group is superior to the T group for visual quality.

Comparison of Corneal Epithelial Thickness Map Patterns in Normal Eyes vs. Eyes With Mild Topographic and Tomographic Abnormalities
RP30061827

Senior Author: Ella G Faktorovich MD

Purpose: To compare epithelial thiness maps (ETMs) in normal vs. eyes with mild topographic and tomographic abnormalities. **Methods:** Retrospective analysis of ETMs (Optovue), topographies, and tomographies in 298 eyes (149 myopes). 190 eyes of 95 patients (Group 1) were normal on topography, tomography, and slit lamp. Eighty-nine eyes of 49 patients (Group 2) had one of these: pachymetry 475-510 (10 eyes/5 patients), inferior steepening <1.5 D (35 eyes/22 patients), superior steepening <1.5 D (16 eyes/8 patients), central steepening (8 eyes/4 patients), claw-shape (14 eyes/7 patients), posterior float (6 eyes/3 patients). Minimal pachymetry thickness (MinP), central epithelial thickness (CenET), ratio of inferior ET to superior ET (Ris), minimal ET (MinET), and difference between maximal ET and minimal ET (Dmm) were compared. **Results:** Group 1: MinP, 533.75 ± 28.26; CenET, 53.60 ± 3.16; Ris, 1.05 ± 0.05; MinET, 49.09 ± 5.08; Dmm, 8.93 ± 2.34. Corresponding measurements in Group 2: 529.19 ± 30.33; 54.60 ± 4.43; 1.05 ± 0.04; 49.72 ± 3.41; 9.42 ± 3.89. $P > .05$ for all variables. **Conclusion:** ETMs in eyes with a single mild topographic or tomographic abnormality were similar to normal eyes in myopes.

Comparison of Results of 3 Methods for Calculation of Topographic-Guided LASIK
RP30061844

Senior Author: Mark C Lobanoff MD

Purpose: To evaluate the results of eyes treated with topographic-guided LASIK based on 3 calculation methodologies: MRx, TMR, and Phorcides. **Methods:** Retrospective analysis of 600 eyes, 200 in each subgroup. Single-surgeon, single-center results of topographic-guided LASIK planned via 3 common methodologies were compared. **Results:** Use of the novel Phorcides software vastly outperformed treatments calculated with manifest refraction or topography modified refraction (measured) methods. Phorcides results also led to better uncorrected visual acuity in patients as compared to the tightly constrained FDA TCAT study. **Conclusion:** Phorcides planning for topographic-guided LASIK appears to produce better patient outcomes than planning based on manifest refraction or TMR.

Higher-Fluence CXL Combined With Partial Wound Resuturing in Severe Post-keratoplasty Astigmatism
RP30061850

Senior Author: Ioanna Kontari MD
Coauthor: A John Kanellopoulos MD

Purpose: Safety and efficacy of a new technique. **Methods:** Fifteen eyes had wound resuturing (wRS) and CXL for post-keratoplasty astigmatism (PKa). Ninety percent depth wound exposure of 180 degrees, 0.1% riboflavin solution and 10-0 nylon sutures were placed prior to CXL (30 mW/cm^2 for 7.2 Joules delivered). **Results:** Mean changes: uncorrected distance visual acuity (UDVA), 20/200 to 20/70; corrected distance VA, 20/50 to 20/25. ECD, PKa: 8.5 D reduction, topography, tomography, and OCT imaging documented improved normalization. **Conclusion:** CXL combined with wRS may offer safe and effective visual rehabilitation in PKa.

Intraoperative Suction Loss in SMILE: Rescue Techniques
RP30061852

Senior Author: Jeewan S Titiyal MD
Coauthors: Manpreet Kaur MD and Farin R Shaikh MD FRCS

Purpose: To describe management of suction loss during SMILE and its outcomes. **Methods:** In case 1, suction loss was observed after 10% of lenticule cut. SMILE was abandoned and flap-based ablative procedure was performed. In case 2, lenticule cut and lenticule side-cut were completed uneventfully and suction loss was observed during cap cut. Eye was redocked, and laser application continued from point of suction loss in rescue mode. Case 3 had double partial peripheral suction loss beyond the treatment zone during lenticule side-cut and cap side-cut, leading to eccentric lenticule and cap side-cuts. Lenticule extraction was uneventful. **Results:** Lenticule could be successfully extracted in all cases. Increased microadhesions were present in case 2 as a result of repeat docking. All cases achieved 20/20 visual acuity. **Conclusion:** Optimal visual and anatomical outcomes can be achieved by successfully managing intraoperative suction loss based on the step-wise algorithm.

Post-DSAEK Topography-Guided PRK: Long-term Refractive and Corneal Imaging Evaluation
RP30061857

Senior Author: Vasilis Skouteris MD
Coauthor: A John Kanellopoulos MD

Purpose: Safety and efficacy of topography-guided PRK (tPRK) treatments after Descemet-stripping automated endothelial keratoplasty (DSAEK). **Methods:** Twelve cases underwent tPRK 8-18 months following DSAEK; perioperative uncorrected distance visual acuity (UDVA), corrected distance VA (CDVA), refractive, keratometric, topography, and tomography data by Scheimpflug and OCT were evaluated for up to 120 months. **Results:** Mean value changes: UDVA from 20/50 to 20/26; CDVA, 20/30 to 20/16; no eyes lost lines of CDVA. All imaging data to include epithelial thickness maps improved by month 3. **Conclusion:** tPRK after DSAEK appears to be safe and very effective in improving visual function.

Novel IOL Power Calculation Following Myopic PRK, LASIK, and RK, Using a Topography-Guided Ablation Simulation
RP30061858

Senior Author: Vasilis Skouteris MD
Coauthor: A John Kanellopoulos MD

Purpose: Refractive accuracy of a novel keratometry-calculation formula for IOL power calculation (IOLpc) after PRK, LASIK, and RK. **Methods:** 112 consecutive cases were evaluated with interferometry-axial length and chamber depth, automated keratometry, topography, and tomography with both Scheimpflug and anterior segment OCT. In the IOLpc (SRK-T, Holliday, Hoffer Q, and ASCRS formulas), the astigmatic power and axis were derived from a topography-guided ablation simulation (tgAS) for a 5-mm optical zone. Uncorrected and corrected distance visual acuity (UDVA, CDVA) and refraction were evaluated up to 12 months. **Results:** Holliday + 2D calculated the highest power and was preferred. Mean values change: UDVA, from 20/75 to 20/24; CDVA, 20/48 to 20/17; refraction in diopters, sphere: –1.5 to –0.5, and cylinder: 1.5 to 0.55. **Conclusion:** IOLpc emmetropia approximation following myopic PRK or LASIK with this novel tpAS appears to be safe and very effective.

Is Standard Clinical Refraction the Optimal Plan in Myopic Topo-Guided LASIK?
RP30061859

Senior Author: A John Kanellopoulos MD

Purpose: To compare 50% and 100% topography-modified refraction (TMR) to the standard clinical refraction (SCR) in myopic LASIK. **Methods:** This prospective, randomized, contralateral-eye study included 260 eyes: 1 eye of each patient was randomized to be treated with TMR either 50% (Group A) or 100% (Group B), the contralateral eye (Group C) was treated with the SCR. The 3-month perioperative visual performance and refractive data were compared for all groups. **Results:** Mean values: UDVA for Group A was 20/18; Group B, 20/16; Group C, 20/20. CDVA: 20/16.75, 20/13.5, 20/20, respectively. One line of vision gained: 41.7%, 55.6%, and 27.8%. Two lines of vision gained: 8.7%, 11.1%, and 5.6%, respectively. In Group A, 17.7% of eyes had over –0.50 D of residual refractive astigmatism; the amount was 11.7% in Group B ($P < .01$) and 27.8% in Group C ($P < .01$). All values were statistically different when Group A was compared to Group B. **Conclusion:** TMR may offer superior visual outcomes when compared to SCR in myopic topo-guided LASIK. 100% TMR appears to be superior to partial TMR adjustment of the SCR.

With-the-Rule vs. Against-the-Rule vs. Oblique Cylinder: Which Eyes Do Better After LASIK, and How?
RP30061860

Senior Author: A John Kanellopoulos MD

Purpose: Comparison of topography-modified refraction (TMR) potential benefit in astigmatic types corrected. **Methods:** 200 myopic wavefront-optimized (WFO) LASIK cases were retrospectively evaluated for uncorrected and corrected distance visual acuity (UDVA, CDVA), refractive error, topography, and tomography. Use of preop data available generated virtual topography-guided LASIK plan with TMR cylinder amount and axis adjustment instead of the actual WFO used, and correlated to current refractive and topographic data available. Comparison between the 3 groups was made. **Results:** with-the-rule (WR), 171; against-the-rule (AR), 10; oblique cylinder (OC), 19. Overall: UDVA, 20/22; CDVA, 20/20; RE in diopters, –0.35 sphere and –0.75 cylinder. >–0.25 D RRC: WR, 76%; OC, 15%; AR, 9%. TMR would have reduced RRC, WR>AR>OC. **Conclusion:** TMR in topography-guided LASIK may offer improved outcomes through accurate cylinder correction in all types of corneal astigmatism.

Corneal Tomography: Scheimpflug vs. Scanning Slit
RP30061862

Senior Author: Athanasios Zissimopoulos
Coauthors: Filippos Vingopoulos MD and A John Kanellopoulos MD

Purpose: To compare Scheimpflug to scanning slit tomography in reproducibility and accuracy. **Methods:** Forty eyes of 20 were imaged 3 times each by the 2 technologies, and their respective data, of a multitude of corneal parameters from the 240 exams, were analyzed and compared statistically. **Results:** Both devices proved accurate in keratometry, cylinder axis, corneal thickness, angle kappa vector (x and y axis average), anterior elevation, and posterior elevation. The Scheimpflug device proved superior ($P < .5$) only in steepest keratometry, corneal thickness, and posterior elevation. **Conclusion:** Corneal tomography with Scheimpflug may be superior to scanning-slit technology, although the 2 methods are both reproducible and accurate.

Outcome of Transepithelial PRK for Extreme Myopia With High-Speed Excimer Laser and Advanced Laser Beam Profile
RP30061865

Senior Author: Mukhtar Bizrah MBBS
Coauthors: Simon P Holland MD and Albert Covello

Purpose: To evaluate outcomes of PRK in eyes with extreme myopia undergoing Schwind Amaris (SA) 1050 SmartSurfACE PRK. **Methods:** Consecutive case series. 122 eyes with extreme myopia (≥10 D) underwent transepithelial (TE) SmartSurfACE PRK. Mitomycin C 0.02% in all cases. Visual outcomes and efficacy and safety indices at each visit for 12 months. **Results:** At 12-month follow-up, 92 (74%) achieved 20/25 uncorrected distance visual acuity (UDVA) postoperatively, while 106 (85%) achieved 20/40. Ninety-six (77%) achieved 20/20 corrected distance visual acuity (CDVA) postoperatively; 70 (57%), preoperatively. Thirty-two (26%) had improved CDVA; 26 (21%) gained ≥2 lines while 2 (2%) lost ≥2 lines. Six had visually significant haze. No retreatments were performed. **Conclusion:** TE PRK with Schwind Amaris1050 SmartSurfACE showed good outcomes with almost three-quarters achieving 20/25 UDVA. Good results with TE-PRK in extreme myopia using the SA1050 are possible for extreme myopia using an advanced beam profile, offering an alternative to LASIK.

Topography-Guided PRK for Correction of Irregular Astigmatism Following Penetrating Keratoplasty
RP30061866

Senior Author: Simon P Holland MD
Coauthors: David T C Lin MD, Albert Covello, Samuel Arba Mosquera PhD, and Shwetabh Verma

Purpose: To evaluate efficacy and safety of topography-guided PRK (TG-PRK) for irregular astigmatism following penetrating keratoplasty (PK). **Methods:** Consecutive case series of contact lens intolerant eyes with irregular astigmatism after PK that underwent transepithelial TG-PRK with Schwind Amaris1050 SmartSurfACE laser (SA) were evaluated at 1 year for refractive outcomes and symptoms. **Results:** Forty-five eyes completed 12 months follow-up, with 16/45 (36%) having uncorrected distance visual acuity (UDVA) ≥ 20/40 compared to none preoperatively. 21 (47%) had corrected distance VA (CDVA) improved, 15 (33%) gained ≥2 lines, 5 (11%) lost ≥2 lines. Mean astigmatism reduced from 4.94 ± 2.35 D to 2.58 ± 2.12 D. Mean spherical equivalent improved from –3.00 ± 3.93 D to –1.49 ± 2.18 D. None showed regression at 12 months. Five delayed epithelial healing without long-term sequelae; 4 had visually significant haze. **Conclusion:** One-year results of TG-PRK with SA for post-PK astigmatism showed satisfactory efficacy and safety. One-third gained 2 or more lines of CDVA, and more than one-third achieved 20/40 UDVA.

Self-Reported Dry Eye Following SMILE
RP30061867

Senior Author: Rose Kristine C Sia MD
Coauthors: Denise Ryan COA MS, Lorie Logan OD, Jennifer Eaddy OD, Samantha B Rodgers MD, Michael P Smith MD, and Bruce A Rivers MD

Purpose: To determine the frequency of dry eye symptoms after SMILE for treatment of myopia. **Methods:** Active duty military service members enrolled in the study (n = 21) were administered with a questionnaire derived from Patient Reported Outcomes with LASIK (PROWL) study before and up to 3 months after SMILE. **Results:** Of the 14 participants (66.7%) who had normal scores preoperatively, 6 reported dry eye symptoms at 1 month (42.9%), and 3 (21.4%) at 3 months postop. Of the 7 participants (33.3%) who had dry eye symptoms at baseline, 2 (28.6%) reported normal scores at 1 month, and 5 (71.4%) at 3 months postop. **Conclusion:** Dry eye symptoms after SMILE seem to be temporary and limited in the early postoperative period.

Topography-Guided PRK for Irregular Astigmatism After Radial Keratotomy Using a High-Speed Laser
RP30061868

Senior Author: Mukhtar Bizrah MBBS
Coauthors: Simon P Holland MD and Albert Covello

Purpose: To evaluate topography-guided PRK (TG-PRK) for irregular astigmatism after radial keratotomy (RK) with Schwind Amaris 1050. **Methods:** Retrospective case series of 33 RK eyes treated with Schwind Amaris 1050 laser and CXL. Data collected at 12 months for analysis: pre- and postoperative uncorrected and corrected distance visual acuity (UDVA, CDVA), manifest refraction, and topographic cylinder. **Results:** Nineteen of 33 (58%) showed UCVA ≥20/40 postoperatively. Seventeen (52%) had improved CDVA; 9 (27%) gained ≥2 lines, while 1 (3%) lost ≥2 lines. Mean astigmatism was reduced from 2.09 ± 1.77 D to 0.97 ± 1.11 D. Mean spherical equivalent was improved from 2.46 ± 1.97 to –0.44 ± 2.01 D. **Conclusion:** Early results of TG-PRK CXL with Schwind Amaris 1050 show efficacy and safety in treating post-RK irregular astigmatism. More than half (58%) had UDVA ≥20/40 at 1 year, and 27% had CDVA improved by ≥2 lines. The technique maybe an alternative treatment for post-RK with contact lens intolerance.

Post-LASIK Ectasia Treated by Topography-Guided PRK and CXL Using a New High-Speed Laser
RP30061869

Senior Author: David T C Lin MD
Coauthors: Simon P Holland MD, Mukhtar Bizrah MBBS, Samuel Arba Mosquera PhD, and Shwetabh Verma

Purpose: To evaluate early results of topography-guided PRK (TG-PRK) for post-LASIK ectasia with CXL with Schwind Amaris 1050. **Methods:** Retrospective case series of 53 ectasia eyes treated with Schwind Amaris 1050 laser and CXL. Data collected: pre- and postoperative uncorrected and corrected distance visual acuity (UDVA, CDVA), manifest refraction, and topographic cylinder. **Results:** Twenty-four had sufficient data at 12 months for analysis. Eighteen (75%) showed UDVA ≥20/40 postoperatively. Nine (38%) had improved CDVA, 5 (21%) gained ≥2 lines, none lost ≥2 lines (P = .03). No patient showed progression. Mean astigmatism was reduced from 3.15 ± 1.50 D to 0.96 ± 0.87 D (P = .0008). Mean spherical equivalent was improved from –2.23 ± 4.06 D to –0.67 ± 1.75 D (P = .05). **Conclusion:** Early results of TG-PRK CXL with Schwind Amaris 1050 show efficacy and safety in treating post-LASIK ectasia. Three quarters had UDVA ≥20/40 at 1 year. In ≥20%, CDVA improved ≥2 lines. The technique may be an alternative treatment for post-LASIK ectasia with contact lens intolerance.

Visual Symptoms in the Early Postoperative Period Following SMILE for Myopia
RP30061870

Senior Author: Denise Ryan COA MS
Coauthors: Rose Kristine C Sia MD, Samantha B Rodgers MD, Lorie Logan OD, Jennifer Eaddy OD, Michael P Smith MD, and Bruce A Rivers MD

Purpose: To evaluate visual symptoms experienced after SMILE. **Methods:** Myopic active duty military service members undergoing SMILE (n = 21) were asked to complete a questionnaire derived from the Patient Reported Outcomes with LASIK (PROWL) studies pre- and up to 3 months post-SMILE procedure. Overall scores ranged 0-100, with a higher score indicating better condition. **Results:** At 1 month postoperatively, the overall scores were significantly worse than baseline for glare (mean difference, 15.5; P = .016) and halo (mean difference, 21.2; P = .02). At 3 months postoperatively, there were no significant differences in the overall scores from baseline for double images, glare, halo, and starburst (P ≥ .177). **Conclusions:** Visual symptoms such as glare and halo may be worse following SMILE but appear to be temporary.

Two-Year Result of Topography-Guided PRK With CXL for Keratoconus With High-Speed Laser
RP30061871

Senior Author: David T C Lin MD
Coauthors: Simon P Holland MD, Mukhtar Bizrah MBBS, Samuel Arba Mosquera PhD, and Shwetabh Verma

Purpose: To evaluate visual symptoms experienced after SMILE. **Methods:** Myopic active duty military service members undergoing SMILE (n = 21) were asked to complete a questionnaire derived from the Patient Reported Outcomes with LASIK (PROWL) studies pre- and up to 3 months post-SMILE procedure. Overall scores ranged 0-100, with a higher score indicating better condition. **Results:** At 1 month postoperatively, the overall scores were significantly worse than baseline for glare (mean difference, 15.5; P = .016) and halo (mean difference, 21.2; P = .02). At 3 months postoperatively, there were no significant differences in the overall scores from baseline for double images, glare, halo, and starburst (P ≥ .177). **Conclusions:** Visual symptoms such as glare and halo may be worse following SMILE but appear to be temporary.

Expectations and Satisfaction of U.S. Military Service Members With SMILE
RP30061873

Senior Author: Bruce A Rivers MD
Coauthors: Rose Kristine C Sia MD, Denise Ryan COA MS, Lorie Logan OD, Jennifer Eaddy OD, Michael P Smith MD, and Samantha B Rodgers MD

Purpose: To determine expectations of and satisfaction with SMILE among active duty U.S. military service members. **Methods:** Participants were asked to complete a questionnaire derived from the Patient Reported Outcomes with LASIK (PROWL) study pre- and up to 3 months post-SMILE for myopia. **Results:** On a scale of 0 to 100 (with higher score indicating lower tolerance of less-than-perfect vision), before SMILE, the overall score for expectations was 70.5 (95% CI, 63.4-77.6). At 3 months postop, 15 of 20 participants had higher vision satisfaction scores compared to baseline (P < .01). The satisfaction with SMILE was also high, with overall score of 83.4 (95% CI, 71.2-95.5), with 100 being highest. **Conclusion:** U.S. military service members seem to have reasonable expectations about spectacle independence and vision clarity after SMILE. They also tend to be highly satisfied with the surgery that they received and their postoperative vision.

Late LASIK Enhancement
RP30061880

Senior Author: Daniela Gomez-Elizondo
Coauthors: Mariana Lopez-Martinez, Julio C Hernandez-Camarena, and Jorge E Valdez-Garcia MD

Purpose: To analyze the outcomes of late LASIK enhancement. **Methods:** A retrospective analysis was performed of patients who underwent LASIK retreatment. **Results:** Nineteen eyes from 11 patients were included. The mean age for the primary treatment and the enhancement were 41 +14.3 SD and 49 years +14.5 SD, respectively. 36.3% of patients were male and 63.6% were female. The mean time between the primary surgery and the enhancement was 101 months, +52.1 SD. 18.2% of the eyes had primary myopic LASIK, while 81.8% had hyperopic LASIK. 57.89% of the LASIK enhancements were of less than 2 D, and 42.1% were between 2 and 6 D. Seventy-nine percent of the eyes showed a post-enhancement uncorrected distance visual acuity (UDVA) of 20/20 or better, and 100% showed UDVA of 20/25 or better. In 100% of cases, a LASIK flap relift was performed. No post-enhancement complications were reported. **Conclusion:** Late LASIK enhancement is a safe option for visual correction.

Intraocular Refractive Surgery

Efficacy of Sutureless Intrascleral-Fixated IOL Implantation for Insufficient Capsular Support
RP30061780

Senior Author: Dan Zhou MD PhD
Coauthor: Lei He

Purpose: To evaluate safety and efficacy of sutureless intrascleral-fixated IOL (SIF-IOL) implantation for patients with insufficient capsular support. **Methods:** Forty-two eyes of 41 patients who underwent SIF-IOL implantation. **Results:** There are 28 male and 13 female cases, with average age of 51.4 ± 18.0 years old. Postoperative complications included anterior chamber fibrin exudation in 3 eyes, mild hyphema or vitreous hemorrhage in 4 eyes, transient high IOP in 6 eyes and low IOP in 8 eyes, iris capture of the IOL in 2 eyes, and exposure of the haptic of IOL in 1 eye. There were significant statistical differences between the postoperative UCVA and BCVA and the preoperative UCVA and BCVA ($P = 0.000$). At the last postoperative visit, mean refractive errors were 0.85 ± 0.47 DS, mean astigmatism was 1.20 ± 0.51 DC. **Conclusion:** The SIF-IOL implantation technique provides good IOL fixation with reliable VA improvement without severe postoperative complication.

Comparison of Outcomes After Phacoemulsification With 2 Different Corneal Incision Distances Anterior to the Limbus
RP30061808

Senior Author: Lijun Wang
Coauthors: Xiting Yang, Jianming Wang, Lei Xiong, and Lin Zhao

Purpose: To compare visual performance and visual quality outcomes after phacoemulsification with 2 different clear corneal incision (CCI) distances anterior to the limbus in senile cataract patients. **Methods:** Retrospective case series. Patients who had undergone phacoemulsification were divided into 2 groups according to the CCI distances anterior to the limbus. The visual acuity, surgically induced astigmatism (SIA), aberrations, anterior segment parameters, and subjective vision quality were evaluated. **Results:** This study enrolled 54 eyes, with 27 eyes per group. Both groups had significant improvement in postoperative uncorrected and corrected distance VA (UDVA and CDVA; $P < .05$). There were no statistically significant between-group differences in postoperative UDVA, CDVA, SIA, corneal aberrations, anterior segment parameters, or VF-QOL questionnaire performance ($P > .05$). **Conclusions:** The phacoemulsification with CCI distances ranging from 0.5 mm to 1.5 mm is an effective and safe therapy for senile cataract.

Pseudopupillary Artefacts in Laser-Assisted Cataract Surgeries: A Case Series
RP30061809

Senior Author: Lional Raj Daniel Raj Ponniah MD

Purpose: To demonstrate the possible pupillary artifacts during femto cataract that lead to imperfections and ways to identify and avoid them. **Methods:** Cases of femto laser–assisted cataract surgeries in which false recognition of reflected artifacts were sensed as pupil and resulted in false oversizing of pupil, leading to complications and very adverse outcomes of irritative exaggerated miosis, accidental laser on the iris surface, inadequate capsulorrhexis, and nucleolysis were analyzed. **Results:** Seven-case series. The various lessons—namely, to cancel pupil autorecognition and to mark pupil manually when in doubt, to look for iris over-shadowing of lens in the capsulorrhexis and nucleolysis zones, and to watch for altered air bubble reflectivity on real-time OCT due to iris pigment release—were learned through different cases. **Conclusion:** Unusual complications following pupillary artifacts do exist, and an extreme amount of caution is to be practiced during automated pupillary recognitions.

Evaluating Visual Performance of Small-Aperture, Accommodating, and Multifocal IOLs
RP30061828

Senior Author: Jay Stuart Pepose MD PhD

Purpose: To assess range and quality of vision with small aperture, accommodating, or multifocal IOLs. **Methods:** Retrospective comparison of 108 IC-8 IOL patients contralaterally implanted with an IC-8 IOL and aspheric monofocal IOL to bilateral implantation of Crystalens AO (n = 26, B+L), Acrysof ReSTOR +3.0 D (n = 25, Alcon), and Tecnis +4D MF IOL (n = 22, J&J). Six-month postop defocus curve and binocular mesopic contrast sensitivity (CS) with and without glare were compared. **Results:** The IC-8 and Crystalens eyes achieved continuous functional range of vision across 4.5 D and 2.5 D, respectively. ReSTOR and Tecnis MF eyes achieved noncontinuous range across 4.5 D and 4.0 D, respectively. The IC-8 and ReSTOR groups were comparable for CS with and without glare. The IC-8 was worse than Crystalens, and at 6 cpd, better than the Tecnis MF at 3 cpd with no glare (P < .05). **Conclusion:** The small-aperture IOL provides broadest continuous visual range and CS comparable to that of accommodating and multifocal IOLs.

Clinical Study on the Effect of Meibomian Gland Treatment on Ocular Surface in Post-LASIK Patients With Meibomian Gland Dysfunction
RP30061835

Senior Author: Qin Tian
Coauthors: Fangrong Cai and Xiaoli Wang

Purpose: To explore the effect of meibomian gland treatment on the ocular surface in post-LASIK patients with meibomian gland dysfunction (MGD). **Methods:** Eighty eyes in post-LASIK patients with MGD were randomly divided into Group A (42 eyes) and Group B (38 eyes). Group A was treated with eyelid cleaning, warm compress, and medication pre-LASIK and cooperated with meibomian gland massage treatment. Group B did nothing. The eye comfort score and breakup time of both groups were compared at 1, 2, and 4 weeks after surgery. **Results:** Compared with Group B at 1, 2, and 4 weeks after surgery, the eye comfort scores of Group A were lower (P < .01); BUT in Group A was significantly longer than that in Group B, and the difference was statistically significant (P < .01). **Conclusion:** Preoperative meibomian gland treatment can effectively promote ocular surface repair in post-LASIK patients with MGD, and stabilize the tear film.

Accuracy of Astigmatism Correction Following Toric IOL Implantation in Eyes With Prior Radial Keratotomy
RP30061843

Senior Author: Ana Laura Caiado Canedo MD
Coauthors: Li Wang MD PhD, Danmin Cao MD, and Douglas D Koch MD

Purpose: To evaluate refractive outcomes of toric intraocular lens (IOL) implantation in eyes with previous radial keratotomy (RK).**Methods:** Toric IOLs were implanted in 73 eyes of 48 patients. The same surgeon performed each operation. The Lenstar LS900 (Haag-Streit AG) was used in this study. Implanted IOLs were either the Alcon lenses (SN6ATx series, Fort Worth, TX, USA) or the Johnson & Johnson Vision lenses (ZCTxxx series, Santa Ana, CA, USA). Vector analysis was performed, and we compared preoperative corneal astigmatism to postoperative refractive astigmatism. **Results:** Preoperatively, 1% and 8% of eyes had corneal astigmatism <0.5 D and <1.0 D, and postoperatively 64% and 81% of eyes had refractive astigmatism <0.5 D and <1.0 D, respectively (P<0.05). The centroid values were 0.91 D @ 1° ± 2.03 D preoperatively and 0.22 D @ 171° ± 0.69 D postoperatively (P<0.05). **Conclusions:** Toric IOLs can be successfully used to treat corneal astigmatism in RK eyes.

Comparison of Visual Outcome in Patients Implanted With Extended Depth of Focus IOLs in Long and Normal Axial Length Eyes
RP30061845

Senior Author: Anjali Badami
Coauthor: Kevin J Everett MD

Purpose: To compare visual outcomes between extended depth of focus intraocular lenses implanted in patients with long and normal axial lengths. **Methods:** This retrospective chart review included assessment of 53 eyes of patients who were referred for cataract surgery and who were candidates for extended depth of focus intraocular lens implantation. Patients were divided into two groups based on axial length: greater than or equal to 25.5 mm and less than 25.5 mm. Resultant visual acuity was measured at distance, intermediate, and near. **Results:** Overall range of vision from distance to near was significantly superior in eyes with long axial length compared to normal axial length. **Conclusion:** Extended depth of focus intraocular lenses appear to be an excellent choice for patients with long axial lengths, providing a superior range of vision.

Does Prior Ophthalmic Surgery Affect the Visual and Refractive Outcomes of Subsequent Toric IOL Implantation?
RP30061847

Senior Author: Osama Mustafa
Coauthors: Christina R Prescott MD, Fares Alsaleh MBBS, Daliya Dzhaber MD, and Yassine J Daoud MD

Purpose: To evaluate visual and refractive outcomes and rotational stability of toric IOLs in eyes with previous ocular surgery. **Methods:** This longitudinal cohort study included 59 cases with a history of ocular surgery and 34 controls. Outcomes were recorded at short-term (1 month), mid-term (3-12 months), and long-term (up to 4.5 years) intervals. **Results:** In the case group, 93.5%, 88.4%, and 86.2% achieved spherical equivalents within ±1.0 D of target at the short-term, mid-term, and long-term follow-up intervals, respectively. Uncorrected distance visual acuity (UDVA) was within 1 line of best corrected distance visual acuity (BDVA) in 79.3%, 77.8%, and 75.0% of cases during the same follow-up intervals, respectively. Postoperative IOL axes were within 5° of intended in 93.9% of cases. Only BDVA was significantly better in controls than in cases postoperatively ($P < .05$). **Conclusion:** Toric IOL outcomes were generally comparable between cases with prior ocular surgery and controls.

Visual Quality and Posterior Capsule Dynamics After Implantation of Hydrophobic Acrylic IOL With UV/Ozone Posterior Surface Modification
RP30061853

Senior Author: Jeewan S Titiyal MD
Coauthors: Manpreet Kaur MD and Farin R Shaikh MD FRCS

Purpose: To assess visual quality after phacoemulsification and correlate with posterior capsule (PC) dynamics. **Methods:** Prospective evaluation of PC dynamics in 42 eyes with hydrophobic acrylic IOL (posterior surface ozone treatment). Primary outcome was PC configuration (wavy/smooth) and adhesion to IOL optic on anterior segment OCT. Secondary outcome was visual quality (aberrometry). Follow-up was performed on postoperative day (POD) 1 and 1 year. **Results:** On POD 1, PC was wavy in 40.5% and smooth in 59.5%; no case had complete PC-optic adhesion. At 1 year, complete PC-optic adhesion was seen in 66.7%. Complete adhesion was significantly higher with initial smooth PC (88.2% smooth, 52% wavy; $P = .02$). Strehl ratio ($P = .011$) and MTF ($P = .027$) were significantly better with complete PC-optic adhesion. PC-optic distance (range: 0-182 µm) positively correlated with total HOA (Pearson coeff. = 0.365, $P = .017$). No association between PC-optic distance and PCO ($P > .05$). **Conclusion:** PC configuration on POD1 impacts final visual quality and adhesion to IOL optic.

Evaluation of a New Concept of Combined Implantation of a Small-Aperture IOL and a Segmental Refractive Bifocal IOL
RP30061854

Senior Author: Gerd U Auffarth MD
Coauthors: Hyeck-Soo Son, Timur Mert Yildirim, Isabella Baur MD, and Ramin Khoramnia MD

Purpose: Clinical evaluation of the visual performance after a combined implantation of a small-aperture IOL (IC-8, Acufocus) in one eye and a segmental refractive bifocal IOL (Lentis Mplus LS-313 MF20, Oculentis, with a near addition of +2.0 D) in the fellow eye. **Methods:** In this prospective study, 26 eyes of 13 patients have been treated. Postop examination includes visual acuity testing, defocus curve, contrast sensitivity, Salzburg Reading Desk (SRD) at the patient's preferred near and intermediate distances, and halo and glare evaluation. **Results:** Mean uncorrected distance visual acuity (VA) was −0.04 logMAR, uncorrected near VA was 0.11 logMAR, and uncorrected intermediate VA was 0.00 logMAR. The reading acuity with SRD was 0.11 (intermediate) in contrast to 0.21 logMAR (near). Numeric value: Halo size, 35.25 (0-68); intensity, 36.33 (0-79); glare size, 14.63 (0-60); intensity, 28.63 (0-50). **Conclusion:** The new concept provided good results at far and intermediate distances as well as functional results at near distance with low levels of photic phenomena.

Novel IOL Power Calculation in Keratoconus Using a Topography-Guided Ablation Simulation
RP30061856

Senior Author: Ioanna Kontari MD
Coauthor: A John Kanellopoulos MD

Purpose: Refractive accuracy of a novel keratometry-calculation formula for IOL power calculation in keratoconus. **Methods:** Forty-two consecutive cases were evaluated with interferometry-axial length and chamber depth, automated keratometry, topography, and tomography with both Scheimpflug and anterior segment-OCT. In the IOL power calculation (SRK-T, Holliday, and Hoffer Q formulas), the astigmatic power and axis were derived from a topography-guided ablation simulation for a 5-mm optical zone. Uncorrected and corrected distance visual abuity (UDVA, CDVA) and refraction were evaluated up to 12 months. **Results:** Hoffer Q calculated the highest power and was preferred. Mean values change: UDVA from 20/400 to 20/32; CDVA, 20/50 to 20/24; refraction in diopters: sphere, −4.5 to −0.5; cylinder, 3.5 to 0.75. **Conclusion:** IOL power calculation for emmetropia approximation in keratoconus with this novel topography-guided ablation simulation appears to be safe and very effective.

Visual and Anatomical Outcomes Post–Phakic IOL Phacoemulsification
RP30061864

Senior Author: Manpreet Kaur MD
Coauthors: Jeewan S Titiyal MD and Farin R Shaikh MD FRCS

Purpose: To evaluate the visual and anatomical outcomes of phacoemulsification after phakic IOL (P-IOL) implantation. **Methods:** Prospective case series of cases with P-IOL in situ requiring phacoemulsification over 5 years. Indication for phacoemulsification, postoperative uncorrected visual acuity, ability to implant IOL, and any complications were recorded. **Results:** Mean time to phacoemulsification was 5.7 ± 3.4 years. Phacoemulsification was performed in 27 eyes for cataract (88.8%), before vitreoretinal surgery (7.4%), and before endothelial keratoplasty (3.7%). Twenty-three eyes had posterior chamber P-IOL, and 4 had iris-claw P-IOL. Etiology of cataract was senile nuclear sclerosis (20), anterior subcapsular cataract with shallow vault (5), and post-traumatic (2). Visual acuity was 20/20 in 88.8% cases and less than 20/200 in cases with retinal or corneal comorbidities. IOL could be safely implanted in 96.3% of cases. No case had PC rent. **Conclusion:** Post P-IOL phacoemulsification has satisfactory outcomes.

Using the First Eye Prediction Error in Cataract Surgery to Refine the IOL Calculation of the Second Eye Using AI
RP30061875

Senior Author: Alain Saad MD
Coauthors: Guillaume Debellemaniere, Mathieu Dubois, Sara Moran, and Damien Gatinel

Purpose: To evaluate the accuracy of the PEARL-DGS contro formula (Precision Enhancement using ARtificial intelligence and output Linearization by Debellemaniere, Gatinel and Saad) for the prediction of postoperative refraction (PPOR) of the second eye following cataract surgery. **Methods:** Biometric parameters of the IOLMaster 700, type of IOL implanted, and postoperative refraction of 1974 patients who underwent bilateral cataract surgery were analyzed. Supervised machine learning was used to optimize IOL prediction error of the second eye based on the prediction error of the first eye in the training set (1928 patients). Evaluation of the derived formula was performed on the validation set. **Results:** Ninety-one percent of the second eye PPOR was within ± 0.5 D. The mean absolute error was 0.237 with PEARL-DGS contro, significantly lower than the other calculated formula (Barrett, Holladay 1, SRK/T, HofferQ). **Conclusion:** The PEARL-DGS contro formula outperformed other formulas in our validation set.

Comparison of the PEARL-DGS IOL Calculation Formula With the ASCRS Calculator Formulas in Eyes With Previous Corneal Refractive Surgery
RP30061877

Senior Author: Guillaume Debellemaniere FEBO
Coauthors: Dubois Mathieu MD, Sarah Moran MD, Rampat Radhika, Arnould Louis MD, Alain Saad MD, and Damien Gatinel MD

Purpose: To compare the results of a new IOL lens calculation formula to formulas available using the ASCRS online calculator in eyes that had a previous corneal refractive surgery. **Methods:** Eyes that underwent cataract surgery in a single center between 2015 and 2018 with a known history of corneal refractive surgery were included. Predicted postoperative spherical equivalents were calculated according to the Shammas, Barrett True K, Double-K, Haigis-L, and PEARL-DGS formulas. **Results:** 130 eyes were included. PEARL-DGS was the best-performing formula in eyes after laser myopic (n = 66) and hyperopic (n = 25) refractive surgery (MAE 0.58, SD 0.54 D and 0.53, SD 0.40 D, respectively), and in eyes after radial keratectomy (n = 39, MAE 0.96, SD 0.89 D). **Conclusion:** The post–corneal refractive surgery version of the PEARL-DGS formula had the best outcomes in all types of post–refractive surgery eyes.

Comparison of Lens Anatomy Parameters Using a Swept Source OCT and Intraoperative Spectral Domain OCT
RP30061878

Senior Author: Larissa Gouvea MD
Coauthors: Matthew Kapeles MD, Jorge Haddad MD, Vinicius DeStefano MD PhD, George O Waring IV MD FACS, and Karolinne M Rocha MD PhD

Purpose: To compare swept source OCT (SS-OCT) optical biometry (IOLMaster 700) lens anatomy parameters obtained pre- and postoperatively with intraoperative spectral domain OCT (SD-OCT; Catalys Precision System) in cataract patients. **Methods:** Preoperative SS-OCT and intraoperative SD-OCT were used to assess lens anatomy parameters. LMP was defined as the distance from the corneal epithelium to the equator of the lens. SS-OCT was used to analyze postoperative IOL position. **Results:** Forty-seven eyes were included in this prospective study. Preoperative ACD and LT were 3.04 ± 0.26 and 4.69 ± 0.28, respectively, with the optical biometry and 3.28 ± 0.23 and 4.69 ± 0.2 with (P = .01, P = .26, respectively). No correlation was seen between LT and LMP (r = 0.1; P = .07) or AL and LT (r = 0.09; P < .01). A positive correlation was seen between ACD preoperative and LMP (r = 0.71; P < .01) and ACD postoperatively and LMP (r = 0.47). **Conclusion:** LMP may be used as a direct measure of ELP and may be useful to improve refractive outomes.

Biometry-Based Prediction of Optimal IOL Power Formula Using Machine Learning
RP30061881

Senior Author: Tingyang Li
Coauthors: Arvind Rao PhD and Nambi Nallasamy MD

Purpose: To develop a machine learning (ML) algorithm that predicts which IOL formula will produce the smallest error in postoperative refraction based on the optical biometry data available for a given eye. **Methods:** Preoperative biometry, IOL implanted, and postoperative refraction data were obtained along with IOL predictions for Barrett, Holladay, and SRK/T for patients undergoing cataract surgery. A random forest classifier was trained. **Results:** A total of 331 cases were identified. Our algorithm predicted the optimal formula in 50.25% of cases (greater than the 33% expected by chance). The distribution of true optimal formula was 41.7% Barrett, 29.9% Holladay, 28.4% SRK/T. The MAEs for Barrett, Holladay, and SRK/T were 0.5235 D, 0.5671 D, and 0.5606 D. The MAE for our algorithm was 0.5221 D, which was lower than each of the 3 formulas individually. **Conclusion:** We created a ML algorithm that outperforms Barrett by automatically selecting the optimal formula for a given patient.

Primary Cornea Guttata in Hispanic Patients Undergoing Cataract Surgery: Corneal Endothelium Morphometry
RP30061883

Senior Author: Andres A Bustamante MD
Coauthors: Julio Cesar Jimenez-Perez MD and Jorge E Valdez-Garcia MD

Purpose: To describe the presence of corneal guttata and corneal endothelial cell characteristics in a population of healthy patients undergoing cataract surgery. **Methods:** Cross-sectional study including 239 corneal endothelium images from healthy subjects undergoing cataract surgery. **Results:** Corneal guttata was noted in 15.48%; mean preoperative endothelial cell density was 2072.9 cells/mm^2 ± 594.5; rate of cell hexagonality, 39.2 ± 8.3%; coefficient of variation of cell area, 45.5 ± 13.5; and central corneal thickness, 527.1 ± 43.43 µm. Significant association was observed between the presence of guttas and subclassifications of female gender ($\chi2 = 4.84$, $P = .028$), endothelial cell density ($\chi2 = 10.175$, $P = .001$), coefficient of variation of cell area $\chi2 = 9.321$, $P = .002$). **Conclusion:** High prevalence of guttata is reported. This could be translated into a potential increased risk in later corneal decompensation after surgery.

Analysis of Static and Dynamic Factors Associated With Pseudoaccommodation in Monofocal IOLs
RP30061884

Senior Author: Karolinne M Rocha MD PhD
Coauthors: Larissa Gouvea MD, Jorge Haddad MD, Thomas Briggs MD, Vinicius DeStefano MD PhD, and George O Waring IV MD FACS

Purpose: To evaluate the factors that influence pseudoaccomodation in pseudophakic patients with aberration-free and negative spherical aberration IOLs. **Methods:** Patients who have had cataract surgery with either ZCBO or MX60E IOLs were recruited. Normal and hyperprolate corneas were included in this study. Patients were divided into 2 groups based upon their distance-corrected near VA: J3 or better and J4 or worse. Pentacam HR and iTrace aberrometry metrics were analyzed including HOAs, VSOTF, EROF, and pseudoaccomodation. **Results:** Fifty-four eyes received a ZCBOO, and 35 eyes received a MX60E. SA was 0.11 ± 0.39 in the J3 or better group and 0.30 ± 0.24 in the J4 or worse group ($P < .01$). Binomial logistic regression demonstrated that eyes implanted with an aberration-free IOL were 3.58 times less likely to be in the J4 or worse group ($P < .01$). **Conclusion:** Patients with monofocal IOLs may have better near visual acuity if implanted with aberration-free IOLs.

Comparison of Ray Tracing, Hartmann-Shack, Autorefraction, and Manifest Refraction in Echelette's Achromatic IOLs
RP30061885

Senior Author: Jorge Haddad MD
Coauthors: Larissa Gouvea MD, Joseana Lopes Ferreira MD, George O Waring IV MD FACS, and Karolinne M Rocha MD PhD

Purpose: To compare ray tracing, Hartmann-Shack, autorefraction, and manifest refraction in patients implanted with achromatic diffractive (Symfony) and a monofocal IOL with negative spherical aberration (ZCBOO). **Methods:** Patients who have had cataract surgery with either a Symfony (Group I) or a ZCBOO (Group II) IOL were recruited. Static measurements using ray tracing and Hartmann-Shack aberrometry and autorefraction were performed 1 to 3 months postoperatively. **Results:** Thirty-two patients were implanted with a Symfony and 24 with a ZCBOO. Manifest refraction was −0.12 ± 0.44 in Group I and −0.15 ± 0.43 in Group II. Autorefractor measurements were closer to plano in both groups (−0.45 ± 0.64, −0.20 ± 0.55, respectively, $P < .001$). Hartmann-Shack showed more myopic results in both groups (−0.85 ± 0.40; −0.45 ± 0.46, respectively, $P < .001$). **Conclusion:** Manifest refraction techniques unique to Echelette's technology should be utilized to avoid over-minus end points.

JRS Hot, Hotter, Hottest: Late Breaking News

In Vivo Evaluation of the Incision Size of 2 Preloaded IOL Devices
RP30061792

Senior Author: Ramin Khoramnia MD
Coauthors: Jan Weindler, Hui Fang, Sonja Schickardt, Isabella Baur, and Gerd U Auffarth MD

Purpose: To compare incision size and cartridge damage after the use of 2 preloaded IOL devices (Clareon AutonoMe, Alcon, and Vivinex iSert, Hoya) intraindividually in patients undergoing cataract surgery. **Methods:** The incision sizes before and after IOL implantation in 68 eyes of 34 patients were measured with the Osher caliper. Furthermore, implantation behavior of the IOLs was evaluated. The tips of all injectors were studied for potential damage by light and electron microscopy. Visual acuity, refractive predictability, and glistenings were evaluated 3 months after surgery. **Results:** Wound stretch was 0.29 ± 0.03 mm for the AutonoMe and 0.36 ± 0.06 for the iSert. Assessment of the injector tips showed the following: (1) AutonoMe: 56%, no damage; 39%, slight scratches; 5%, slight cracks. (2) iSert: 5%, slight scratches; 43%, slight cracks; 52%, extensions. **Conclusion:** The AutonoMe injector causes less wound stretch of the incision and shows less damage at the injector tip than its counterpart, iSert.

Assessment of Postoperative Haze After Deep Transepithelial PRK Without Mitomycin Using a New Ablation Algorithm to Smoothen the Stromal Wound Bed
RP30061797

Senior Author: Francesca Gilardoni MD
Coauthors: Emilio Torres-Netto MD, Reyhaneh Abrishamchi MD, Nikki Hafezi, and Farhad Hafezi MD PhD

Purpose: To assess corneal haze after transepithelial PRK with stromal ablation of more than 100 µm for myopic astigmatism, without the use of mitomycin C. **Methods:** We retrospectively collected clinical data preoperatively and at 1 and 3 months after surgery, including haze assessment at the slit lamp and with densitometry analysis of Scheimpflug images. **Results:** We evaluated 21 eyes from 12 patients. Mean stromal ablation was 106.14 µm. We detected a significant increase in densitometry in the central 2 mm of the intermediate layer, a significant decrease in the anterior 120 µm, and no change in the remaining layers. At the slit lamp, haze was insignificant at all time points. **Conclusion:** Deep stromal ablation of more than 100 µm without the use of mitomycin C did not result in clinically relevant haze. The use of mitomycin C in deep ablation PRK may not be essential in a central European setting and using a novel excimer laser ablation profile.

Individualized CXL in Ultra-Thin Corneas: Two-Year Follow-up
RP30061798

Senior Author: Francesca Gilardoni MD
Coauthors: Emilio Torres-Netto MD, Sabine King PhD, Nikki Hafezi, Farhad Hafezi MD PhD

Purpose: To analyze whether individualized CXL with adapted fluence can stop keratoconus progression in ultra-thin corneas up to 24 months after treatment. **Methods:** Forty-five progressive keratoconus eyes with stromal thicknesses between 305 µm and 398 µm were enrolled. UV irradiation was performed at 3 mW/cm^2 for 7 to 25 min. Eyes were examined preoperatively and at 6, 12, and 24 months postop. Five of 45 eyes showed progression within 12 months. **Results:** A significant correlation was found between demarcation line depth and both irradiation time and changes in densitometry. On average, there was a significant change at 12 months in minimal thickness, Kmax, and densitometry. No significant changes were found in visual acuity and refraction. **Conclusion:** Progression was arrested in 89% of eyes at 12 months. Demarcation line depth did not predict treatment outcome and is likely not related to the extent of CXL-induced corneal stiffening, but rather to the extent of induced wound healing.

Stromal Bed Smoothness After Excimer Laser Surface Ablation as a Key Element for the Expression of Inflammatory Genes
RP30061801

Senior Author: Emilio A Torres Netto MD
Coauthors: Sabine Kling PhD, Arthur Hammer MD, Samuel Arba Mosquera PhD, Thomas Magnago, Nikki Leilah Hafezi, and Farhad Hafezi MD PhD

Purpose: The purpose of this experimental in vivo study was to determine whether algorithms and energy optimizations of ablation profiles differed in gene expression, especially those concerning inflammatory response. **Methods:** Sixty-six eyes were included in this 3-phase study. Eyes were subjected to PRK and divided into groups varying fluence, frequency, and optimization of corneal smoothness (OCS). Rabbits were euthanized and corneas prepared for gene expression analysis. **Results:** PCR revealed 22 genes related to inflammation and significant differences between treated groups. However, when OCS was used, coding transcriptome analysis showed only significant differences between control and treated eyes. **Conclusions:** The optimization of different algorithms or energy settings allows for reduction of the inflammatory response after refractive laser surgery. Controlling stromal bed smoothness and, thus, haze may allow not only for deeper ablations but also for the development of future ablation profiles.

Biomechanical Effect of CXL in Fellow Human Corneas Following SMILE or PRK in an Ex Vivo Model for Postoperative Ectasia
RP30061802

Senior Author: Emilio A Torres Netto MD
Coauthors: Bogdan V Spiru, Sabine Kling PhD, Francesca Gilardoni MD, Apostolos Lazaridis MD, Walter Sekundo MD, and Farhad Hafezi MD PhD

Purpose: To evaluate the biomechanical effect of CXL in fellow human corneas following SMILE or PRK in an ex vivo model for postoperative ectasia. **Methods:** Twenty-six paired human corneas were divided: right and left corneas were treated with PRK and SMILE, respectively. Corneas underwent stretching with cycles of up to 9.0 N to induce biomechanical weakening. Accelerated CXL was performed and elastic modulus (EM) was calculated. **Results:** Following CXL treatment, the ectasia-like corneas, pretreated with either PRK or SMILE, showed a mean EM of 17.28 (SD = 5.28) MPa and 14.18 (SD = 5.03) MPa, respectively. There was no significant difference between both groups ($P = .093$). **Conclusion:** The biomechanical properties of ectasia-like corneas treated with CXL were equivalent, whether the pretreatment was performed with SMILE or PRK. Our data suggest that in the event of postoperative ectasia, the biomechanical improvement achieved by CXL may be similar regardless of whether the primary surgery was PRK or SMILE.

Comparison of Clinical Outcomes After Bilateral Implantation of 3 Trifocal IOLs Differing in Optic Design and Material
RP30061812

Senior Author: Ramin Khoramnia MD
Coauthors: Florian T A Kretz MD, Matthias Gerl, Detlev R H Breyer MD, and Gerd U Auffarth MD

Purpose: Assessment of near, intermediate, and far visual acuity with trifocal IOLs. **Methods:** In this ongoing prospective multicenter study, 100 subjects received bilateral IOL implantation with hydrophilic and hydrophobic trifocal IOLs (POD F and POD F GF, both PhysIOL) and AcrySof IQ (PanOptix, Alcon). **Results:** Preliminary results of 58 patients, up to 6 months follow-up (116 eyes), shows POD F and POD F GF achieve refractive outcomes close to emmetropia across all follow-up visits, whereas PanOptix shows significantly hyperopic outcomes of 0.38 ± 0.35D ($P = .006$). Postoperative mean corrected distance visual acuity (VA), distance-corrected intermediate VA, and distance-corrected near VA in logMAR are −0.02 ± 0.10, 0.08 ± 0.09, and 0.06 ± 0.11 for POD F; 0.00 ± 0.09, 0.13 ± 0.12, and 0.15 ± 0.17 for POD F GF, and 0.00 ± 0.10, 0.10 ± 0.13, 0.15 ± 0.12 for PanOptix, respectively. The differences on visual acuity were not significant ($P > .05$). **Conclusion:** The 3 trifocal IOLs successfully restored good vision at far, intermediate, and near distances with minor differences in the clinical outcomes.

Corneal Laser for Dry AMD Patients
RP30061837

Senior Author: Raymond M Stein MD
Coauthors: Samuel Markowitz and Michael Berry

Purpose: To evaluate the safety and efficacy of a new corneal laser procedure for treating dry AMD patients. **Methods:** Fifty-seven pseudophakic dry AMD eyes (mean BCVA of 20/273; logMAR: 1.135) of 32 patients (16 F, 16 M; mean age: 81.0 years) received corneal laser treatments. Examinations included BCVA, potential visual acuity (PVA), and National Eye Institute Visual Function Questionnaire (VFQ-25). **Results:** Safety: No complications or adverse events occurred. Efficacy: Mean BCVA improvements were significant ($P < .05$), with 9.2 and 8.7 mean letters gained at 1 and 3 months post-treatment. VFQ-25 exams demonstrated that vision-related quality of life improved. **Conclusion:** The new corneal laser treatment is safe and efficacious for improving vision and quality of life for dry AMD patients. The procedure is noninvasive, simple, rapid, and comfortable.

Temporal Myopic Shift Following Instillation of Bimatoprost Ophthalmic Solution
RP30061842

Senior Author: Manami Kuze MD
Coauthors: Moto Kataoaka and Masahiko Ayaki MD

Purpose: The major mechanism by which the prostaglandin analogue bimatoprost (BM) reduces IOP is accelerating uveoscleral flow where the ciliary muscle controls accommodation. This study assessed temporal changes in refraction and accommodation after instillation of BM (AIB). **Methods:** We examined refraction and accommodation before and at 5, 10, and 60 min AIB. **Results:** Eleven normal subjects (mean age: 46.7 years) were recruited. The mean refractive error (D) was −0.6 ± 2.2 before and −0.2 ± 2.2 at 60 min AIB, showing no significant difference ($P = .31$). In contrast, the near add power (NAP) (D) before and at 5, 10, and 60 min AIB was +2.2 ± 0.7, +1.9 ± 0.7, +2.0 ± 0.7, and +1.9 ± 0.8, respectively. NAP was reduced by 0.3 ± 0.3 at 5, 0.2 ± 0.4 at 10, and 0.3 ± 0.4 at 60 min AIB, indicating a statistically significant myopic shift ($P = .001$). **Conclusions:** BM induces a myopic shift and could potentially decrease NAP.

Refractive Results From Phorcides-Planned Contoura
RP30061846

Senior Author: Mark C Lobanoff MD

Purpose: To evaluate the results from 4 centers using Phorcides-planned Contoura LASIK. **Methods:** Retrospective review of Phorcides Contoura results from 4 separate LASIK centers. **Results:** Phorcides Contoura produced 3-month postop results of 97% 20/20 UCVA and 80% 20/15 UCVA. **Conclusion:** Phorcides planned Contoura LASIK treatments proved to be exceptionally accurate, yielding superb visual results.

School Screening for Keratoconus: An Idea Whose Time Has Come
RP30061855

Senior Author: Samuel E Navon MD PhD

Purpose: To create and test a cost-effective model for the universal school screening of keratoconus in high-risk populations. **Methods:** 500 Emirati students between 10 and 16 years of age were screened for keratoconus using a short questionnaire and corneal tomography. The scans were analyzed by several validated decision trees. **Results:** The prevalence of keratoconus and keratoconus suspects was 2.5% and 8%, respectively. Assuming a 5% rate of clinically significant progression for the suspects, we estimate a health care savings of 1 million US dollars per million general population in the presence of national screening. **Conclusion:** Our findings support growing evidence of a high prevalence of keratoconus in the Middle East and suggest that school screening during mid to late adolesence is potentially extremely cost-effective.

Updates in Refractive Surgery

Optical Quality Metrics Comparison Between Forme Fruste Keratoconus and Normal Eyes
RP30061796

Senior Author: Mark Krauthammer MD
Coauthors: Emmanuel Bettach, Adi Abulafia MD, Avi Shoshani, David Zadok MD, and David Smadja MD

Purpose: To compare optical quality metrics in patients with form fruste keratoconus (FFKC) and patients with normal corneas using high-definition double-pass system analyzer. **Methods:** Twenty patients with FFKC and 60 with normal corneas were included. Corneal tomographic parameters were obtained with Galilei dual-Scheimpflug analyzer. A double-pass retina point high-definition analyzer (HDA) was used to collect the following optical quality metrics: objective scatter index (OSI), modulation transfer function (MTF), and Strehl ratio. **Results:** There was a statistically significant deterioration in the measured optical quality metrics of patients with FFKC as compared to normal corneas, as follows: Mean OSI were 0.76 vs. 0.42 ($P < .001$); mean MTF, 37.0197 vs. 50.1411 ($P < .001$); and mean Strehl ratio, 0.2168 vs. 0.2616 ($P = .01$), respectively. **Conclusions:** HDA helped in identifying decrease in optical quality of FFKC patients. It might be suggested as an additional diagnostic tool for identifying earlier forms of keratoconus.

Visual and Refractive Outcomes and Tomographic Changes of 1-Segment Femtolaser-Assisted Intrastromal Corneal Ring Implantation Based on Severity of Keratoconous
RP30061806

Senior Author: Seyed Javad Hashemian MD

Purpose: To assess the visual and refractive outcomes and tomographic changes after implantation of a single-segment intrastromal corneal ring (ICRS; Intacs SK) in the early stages of keratoconous. **Methods:** One-segment Intacs SK was inserted using a femtosecond laser into eyes with stage I–II keratoconus. Visual and refractive outcomes and corneal tomography changes were analyzed 6 months postoperatively. **Results:** The study evaluated 155 eyes of 123 patients. At 6 months the SE, mean sphere, and mean cylinder were decreased by 0.97, 1.22, and 1.29 D, respectively. The mean preoperative uncorrected uncorrected and corrected distance visual acuity (UDVA and CDVA) increased from 0.78 to 0.39 and from 0.45 to 0.18 logMAR, respectively. Steep and flat keratometry, mean K, and anterior and posterior best feet sphere decreased significantly; 94.0% of eyes gained 1 or more lines of CDVA. **Conclusion:** Implantation of 1-segment Intacs SK is safe and effective to treat early keratoconus, leading to significant improvement in UDVA, CDVA, and refractive error.

Femto-Assisted Intracorneal Stromal Addition Followed by Residual Refractive Correction in Lens Plane Reverses Advanced Keratoconus: A Novel Concept
RP30061810

Senior Author: Lional Raj Daniel Raj Ponniah MD

Purpose: To evaluate toric phakic IOL (P-IOL) as add-on measure to corneal stromal augmentation (CSA) in advanced keratoconus. **Methods:** In phase 1, femto-assisted donor lenticule was transplanted into a midstromal recipient, femto-dissected corneal pouch. Followed at 1 year. In phase 2, residual refractory errors were treated with P-IOL, followed at 6 months. **Results:** In phase 1, $n = 15$. UCVA and BCVA improved from 1.2 ± 0.2 to 0.8 ± 0.2, and 0.9 ± 0.2 to 0.4 ± 0.1. CCT was restored to 583 mic. Corneas flattened (anterior, 0.067 to 0.044; posterior, 0.075 to 0.039). Astigmatism reduced from 9.2 ± 4.3 D to 4.3 ± 1.7 D. In phase2 ($n = 8$), residual sphere and cylinder were -3.87 ± 2.21 and -4.18 ± 0.84 D. BCVA was 0.22 $\pm$ 0.04 at 6 months with normal CSF and HOA. **Conclusions:** CSA improved vision, flattenned cornea, increased pachymetry, and improved irregular astigmatism without loss of tissue and sutures. Add-on toric phakic IOL is an effective refractive solution.

Relationship Between Corneal Topography and Astigmatism
RP30061814

Senior Author: Deeksha Rani Jr MS
Coauthors: Sudarshan K Khokhar MD FRCS(ED), Chirakshi Dhull MD, and Yogita Gupta Jr MBBS

Purpose: To establish the relationship between corneal topography and astigmatism. **Methods:** Forty-nine eyes of 26 patients (7-24 years) with 2-7 D astigmatism were followed up for 3 years with corneal topographic analysis with Pentacam (Oculus Pentacam HR) and with Belin/Ambrosio enhanced ectasia display (BAD). **Results:** The mean and maximum keratometry was 44.2 ± 1.4 D and 47.0 ± 2 D, respectively. Mean thinnest pachymetry was 525.4 ± 47.5 µm. The mean D-value was 1.91 ± 1.1. The majority of corneas (73.5%) were normal, with forme fruste keratoconus in 10.2% and keratoconus in 16.3%. **Conclusion:** Most of the patients had a normal corneal topography which remained normal over time. There is a risk of developing keratoconus; hence all such patients should undergo detailed evaluation. However, there is no significant correlation between corneal pachymetry, topography, and astigmatism. The amount of astigmatism is not directly related to the risk of keratoconus.

Mitomycin C Use Does Not Improve Visual Outcomes and Rates of Corneal Inlay Explantation in Patients Receiving a Shape-Changing Hydrogel Inlay
RP30061838

Senior Author: Navaneet S C Borisuth MD PhD
Coauthors: Neeraj Singh Chawla BS and Saneha Kaur Chailert Borisuth

Purpose: To evaluate the visual and clinical outcome of patients undergoing implantation of the Raindrop Near Vision Inlay with and without mitomycin C (MMC) application. **Methods:** Retrospective analysis of 30 eyes of 30 patients undergoing inlay implantation (MMC, 10 eyes; no MMC, 20 eyes) with a minimum of 2 years follow-up. We assessed near acuities, corneal haze, and rates of explantation. **Results:** In the inlay eye, UNVA >20/25 was achieved in 44% of MMC eyes and 52% of eyes not receiving MMC. Visually significant corneal haze developed in 50% of all eyes (MMC, 4/10; no MMC, 11/20). MMC use was not significantly correlated with improved reading vision (Pearson coefficient $r = 0.12$), grade of haze ($r = -0.08$), or prolonged use of topical steroids for haze ($r = -0.13$). The explantation rate was 50% in the MMC and 30% in the no MMC groups. **Conclusion:** MMC use did not improve the visual outcomes and did not result in lower explantation rates of a shape-changing inlay.

Linking the Eye to the Brain: How Functional MRI Helps Us Understand Neuroadaptation to Multifocal IOLs
RP30061839

Senior Author: Mariana Almeida Oliveira MD
Coauthors: Andreia Martins Rosa MD, Amelia Sofia Correia Martins, Elisabete Almeida, Miguel Castelo-Branco, and Joaquim N Murta MD PhD

Purpose: To assess changes in the visual cortex after multifocal IOL implantation using functional MRI (fMRI). **Methods:** Prospective cohort study of 30 patients with sequential bilateral implantation of a diffractive multifocal IOL (ReSTOR SN6AD1) and a control group ($n = 15$). Structural and functional MRI scans were performed at the third week and sixth postoperative month. Controls' scans were performed with the same time interval. **Results:** Glare decreased the signal obtained for the sinusoidal grating at the first visit ($P = .040$), but not at 6 months. Patients had increased activity of cortical areas dedicated to attention, learning, cognitive control, and task goals in the first visit, which normalized at 6 months. No improvement occurred in optical properties. Control group had no significant changes. **Conclusion:** The recruitment of visual attentional and procedural learning networks of the human brain leads to neuroadaptation after multifocal IOL implantation.

Use of High-Resolution OCT and Scheimpflug Imaging to Enhance IOL Calculations in Post–Myopic LASIK Cataract Eyes
RP30061840

Senior Author: Neeraj Singh Chawla BS
Coauthors: Saneha Kaur Chailert Borisuth and Navaneet S C Borisuth MD PhD

Purpose: To compare the accuracy of a high-resolution Scheimpflug camera–based formula (Potvin-Hill) and a spectral domain OCT–based formula to the ASCRS calculator for previous myopic LASIK eyes undergoing phacoemulsification (PE) with standard (SV) and premium IOLs (P-IOLs). **Methods:** We analyzed 125 eyes undergoing SV (70 eyes) or P-IOL (20 toric, 35 EDOF) implants. Postoperative refractive data were used to compare back-calculated optimum IOL powers (BCO) and to derive the absolute prediction error (AE). **Results:** BCO was most accurate for the Masket formula (AE = 0.49), Potvin-Hill (0.50), Average (0.50), Barrett True K (0.50), OCT (0.55), Modified Masket (0.55), Haigis-L (0.57), and Shammas (0.65). 76.7% and 86.9% of eyes fell within ±0.5 D and ±1.0 D of target predicted refraction. **Conclusion:** The Masket, Potvin-Hill, Average, and Barrett formulas most effectively predicted refractive outcomes. Total corneal power measurements with the Scheimpflug system outperformed the OCT in predicting refractive outcomes.

Advanced IOL Power Calculations Using High-Resolution Scheimpflug Imaging in Post-LASIK Eyes Undergoing Cataract Surgery With Astigmatism Correction
RP30061841

Senior Author: Neeraj Singh Chawla BS
Coauthors: Saneha Kaur Chailert Borisuth and Navaneet S C Borisuth MD PhD

Purpose: To analyze the accuracy of advanced IOL power calculations using the Pentacam AXL measurement of total corneal refractive power (TCRP) in post-LASIK eyes undergoing phacoemulsification (PE) with astigmatism correction. **Methods:** Thirty eyes of 20 patients underwent PE with toric IOL (*n* = 10) or laser arcuate keratotomy and PE with single vision (SV) (*n* = 10) or extended-range (EDOF) (*n* = 10) IOLs. We compared the absolute error (AE) in predicted refractive astigmatism for TCRP in a 4-mm zone centered on the pupil to that of standard keratometry (SK). **Results:** The AE in refractive astigmatism was 0.66 ± 0.42 D using SK and 0.57 ± 0.48 D using the TCRP algorithm (*P* = .43). **Conclusion:** Using the high-resolution Pentacam AXL TRCP measurement, we were able to lower the error in postoperative refractive astigmatism in LASIK eyes undergoing PE with astigmatism correction. However, the difference was statistically nonsignificant.

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