JUNE 2018 # 22

the Ophthalmologist™

Model Surgery

From humble beginnings to a new standard of surgical training models: Stuart Stoll shares his journey of invention.

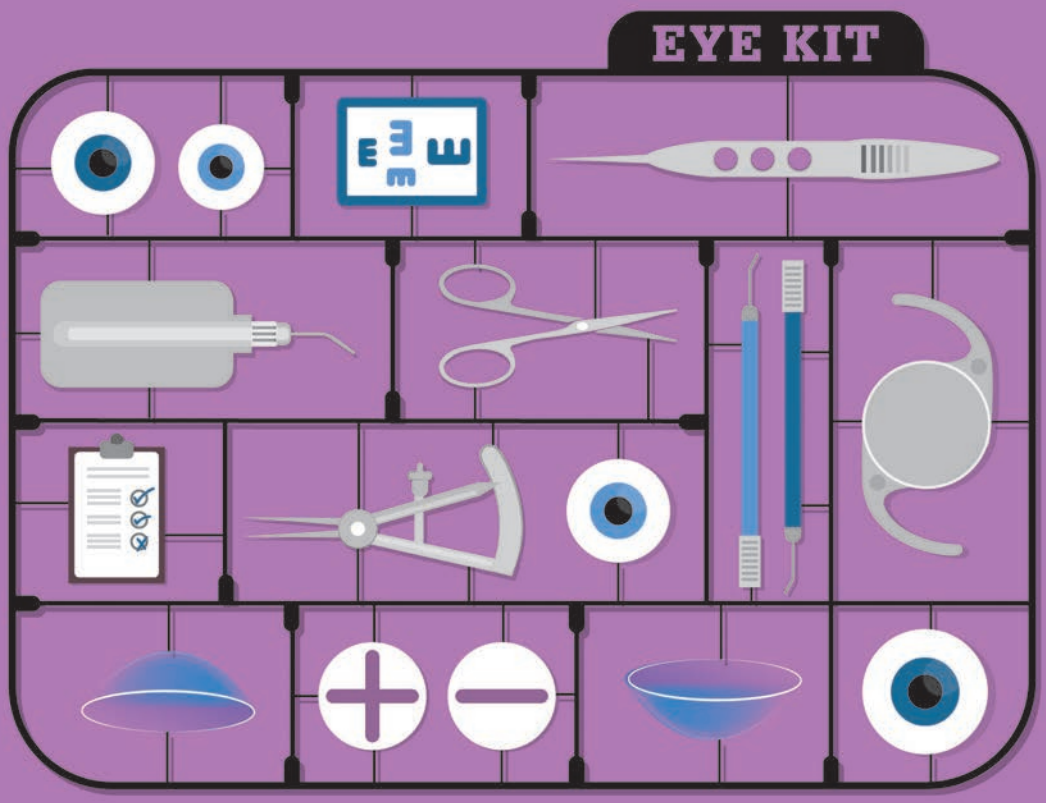

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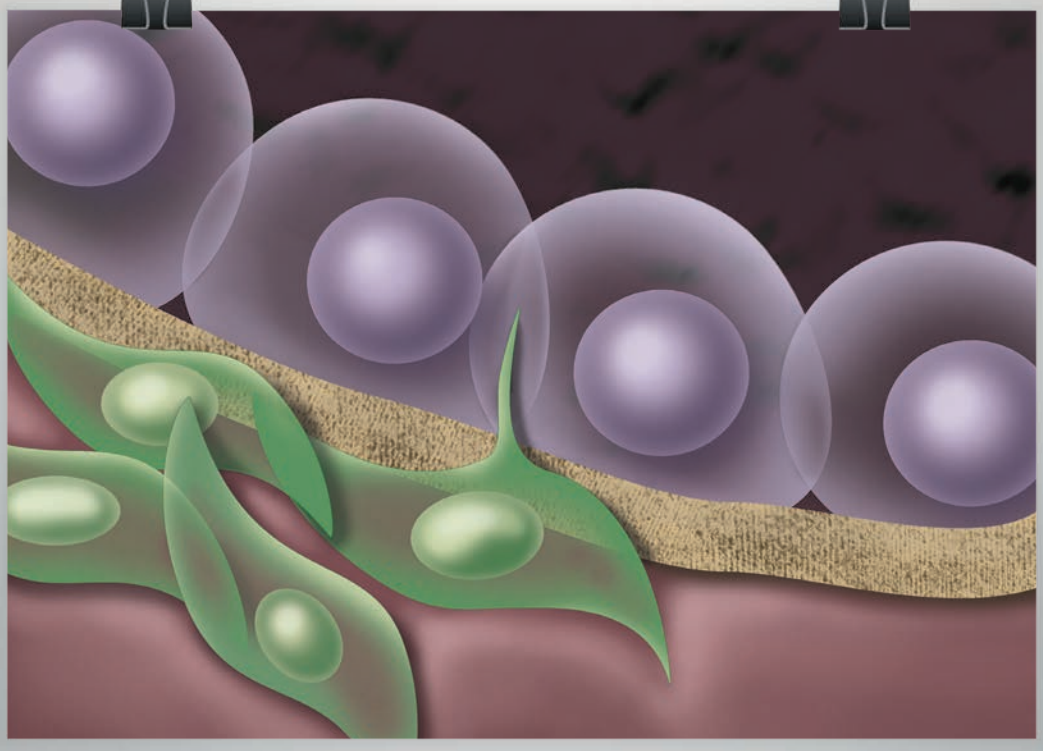
Image of the Month



A Niche Window

This image accompanies Medi Eslani's article "Rebuilding the Niche" on page 15, and shows the interaction between limbal epithelial stem cells (LESCs; purple) and mesenchymal cells (MSCs; green) in the limbus. In their niche, LESCs interact closely with extracellular matrix components, melanocytes, immune cells, blood vessels, nerves and MSCs. MSCs have a major regulatory role in the LESCs' niche, and in maintaining LESC biology.

Credit: Medi Eslani, University of Illinois at Chicago, Chicago, IL, USA.

Do you have an image you'd like to see featured in The Ophthalmologist? Contact edit@theophthalmologist.com.

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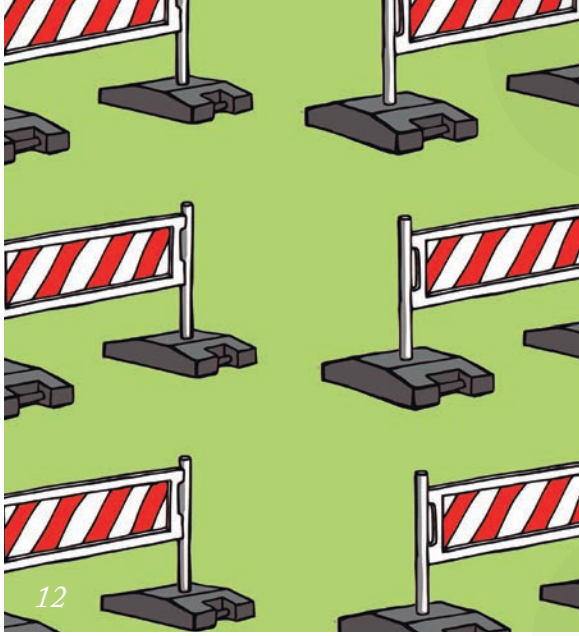


In My View

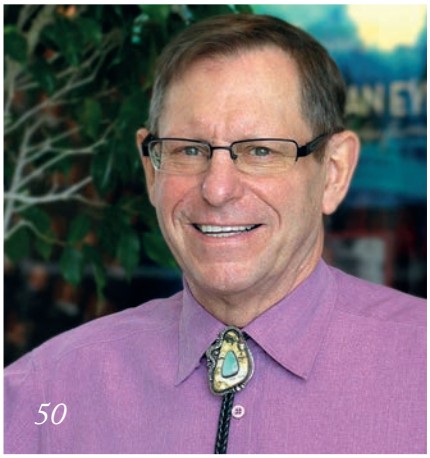
Upfront

Features

On The Cover

Inspired by off-the-shelf kits, we present the model eye kit for surgeons.

In Practice



NextGen

Profession

Sitting Down With

the Ophthalmologist

ISSUE 22 - JUNE 2018

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The Curse of Indecision

Why are many potential refractive surgery patients – myself included – not pulling the trigger on vision correction?

As a contact lens-wearing – and occasionally bespectacled – individual, I have often toyed with the idea of refractive surgery. No more worrying about being able to see when swimming or donning super-tight goggles (if I 'break the rules' and leave my lenses in); no more having to wrestle myself out of bed to remove forgotten contact lenses while half asleep; and, best of all, no more having to shell out money every month to navigate the world with unimpaired vision. What has held me back? Honestly, I am not quite sure. But as I sit here, eyes mildly irritated by my annual bout of hay fever, proofing articles from our Modern LASIK panel (www.theophthalmologist.com/modernlasik), not for the first time, I find myself considering the benefits of refractive surgery – and wondering why the numbers of people opting for refractive surgery have been (and still are) in decline. As Dan Reinstein points out, "LASIK uptake has dropped from 1.6 million procedures per year in the US to 0.6 million today – we're doing fewer procedures, even though we're 50 times safer."

Why, in an era of advanced procedures with excellent safety and visual outcomes, is this? Cost is certainly a factor for some. Maybe a little fear of the procedure itself; it's true that many myths and 'scare stories' surround the procedures, but ophthalmologists – and patient advocates – are working hard to overturn these. But I can't help but wonder if it might also be a result of indecision – and a lack of drive to pursue treatment in the face of current life milestones and 'pressures'.

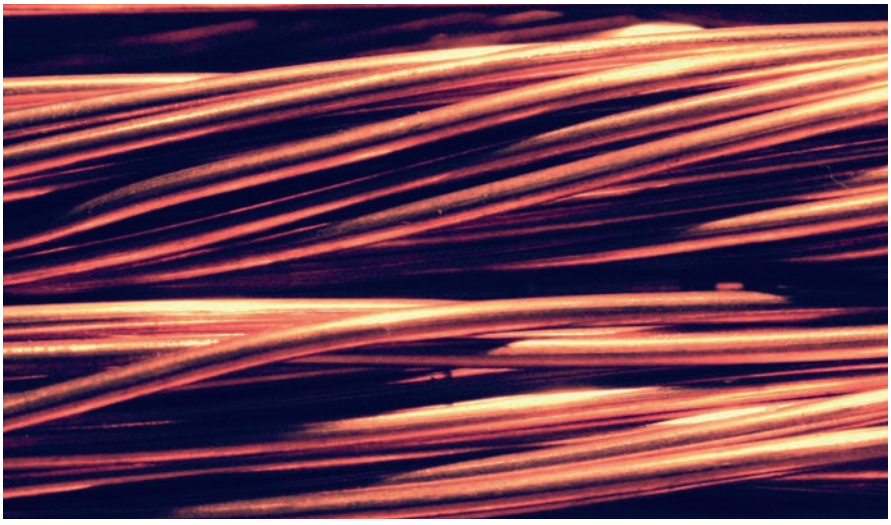
Will I opt for refractive surgery one day? I'd like to think so. What will make me actively go out and seek it? I am still not quite sure. It seems to me that understanding the tipping point that pushes prospective patients from "I would like do that, but [insert reason here]" to "I *must* do that," would benefit ophthalmologists and their patients alike. It is abundantly clear that refractive surgeries are here to stay, and will only get better and better... Perhaps, I have just talked myself into it. Or maybe I haven't.

Ruth Steer
Managing Editor

Upfront

Reporting on the innovations in medicine and surgery, the research policies and personalities that shape the practice of ophthalmology.

We welcome suggestions on anything that's impactful on ophthalmology; please email edit@theophthalmologist.com



Time to Say CU KC?

Copper drops for the treatment of keratoconus

Glaucoma treatment may be moving away from the humble eyedrop in favor of sustained-release drugs and minimally invasive technologies, but the treatment of keratoconus could be moving towards it.

IVMED-80 is a copper-based topical treatment for keratoconus that is currently under investigation by iVeena Delivery Systems, Inc, (founded by Bala Ambati, Professor of Ophthalmology, University of Utah, Salt Lake City, UT, USA). IVMED-80's mechanism of action is believed to center on enhancing the activity of lysyl oxidase (LOX) – the enzyme responsible for corneal collagen crosslinking, and also known to be associated with keratoconus (1).

The essential cofactor for the enzyme? Copper. "And that led us to our hypothesis that if we supplement with copper, we could enhance LOX activity and corneal stiffening," says Sarah Molokhia, Vice President of Research and Development at iVeena.

Applying IVMED-80 to human corneal stromal cells, the team found that LOX activity increased 10-fold in cells from keratoconic corneas, compared with a four-fold increase in normal stromal cells. They also found that human cadaver corneas treated with IVMED-80 showed improvements in radial strain. Moving to in vivo studies in New Zealand white rabbits, the team found that after four weeks of treatment, there was a flattening in corneal topography and corneal stiffness was increased (2). "We also found that our one month data was comparable with human data of UV-mediated crosslinking at six months," says Molokhia.

The team is currently preparing for publication of their pre-clinical results, and plan to move into human trials by the end of 2018. Could patients soon be saying good-bye – or 'C u' – to keratoconus?

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Automated AMD Assistance

Could a new image analysis technique contribute to earlier or more accurate diagnosis of AMD?

What do orbiting satellites and ophthalmic imaging techniques have in common? Both may soon benefit from computerized pattern recognition to improve their accuracy. Researchers from the University of New South Wales applied multispectral, unsupervised pattern recognition – the same method currently used to develop satellite maps – to 184 fundus images to see whether or not the technique might improve their quantification and classification, leading to better diagnosis of diseases like AMD (1).

The idea itself is not new – senior author Michael Kalloniatis says the possibility first occurred to him 14 years ago – but the technology has only now reached the point where inspiration can become reality. "We could only test the hypothesis once these imaging techniques became more established," he said (2). And that day seems to have arrived. In Kalloniatis' study, which examined 10 normal eyes and 36 with intermediate AMD, the pattern recognition approach demonstrated 74 percent sensitivity and 98 percent specificity in detecting AMD lesions, and further correctly classified 75 percent of large drusen and 68 percent of pigmentary abnormalities.

Does this mean ophthalmologists can now leave the diagnostic work to their computers? Not quite. The method is a powerful new way to integrate multiple imaging modalities and combine their strengths, but it still relies on a supply of accurate and appropriately processed images from each individual modality. Unprocessed images, the authors warn, are susceptible to errors caused by both physical (choroidal vasculature visibility, fundus pigmentation) and technical (non-macular signatures, background intensity gradient) variations.

This approach, like all imaging techniques, is not intended to replace traditional imaging and funduscopy; rather, the authors hope it will serve as an enhancement. And who knows – one day in the not-too-distant future, this technology might even form part of an automated diagnostic or clinical decision support tool that could enable the earlier detection of AMD.

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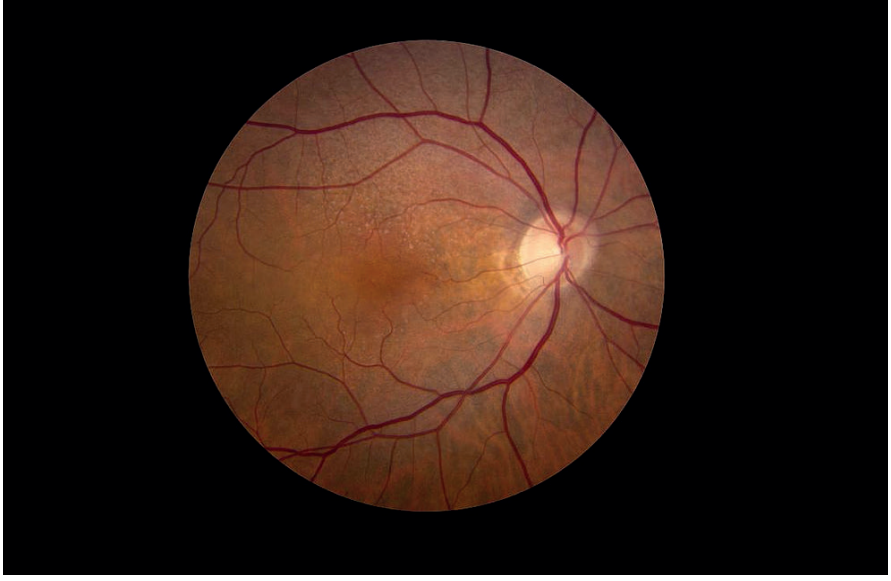

DIY OCT

A hand-held device that aims to reduce the disease burden for AMD patients

AMD may well be treatable with anti-VEGF injections, but it comes at a cost to the patient: regular visits to the ophthalmologist's office for disease monitoring with OCT. For elderly and visually impaired patients who require travel assistance, these frequent appointments can represent a further burden on their relatives – or their finances. A team from Universitätsklinikum Schleswig-Holstein, Kiel, and Medical Laser Center, Lübeck, Germany, have a potential solution in the form of a hand-held OCT device for home-monitoring of patients with retinal disease.

Given today's advanced – and costly – OCT systems, what does a home-care setup look like, and how can it be achieved? "For a device to be used by the patients themselves, it needs to be small and low-cost," explains Claus von der Burchard, Research Fellow at Universitätsklinikum Schleswig-Holstein. "To get there, we've had to make some compromises on image quality." The result is off-axis full-field time-domain OCT (1). Von der Burchard explains: "We focused on reducing the scan area to 3 x 3 mm and using a full-field system which illuminates the whole field." According to von der Burchard, the 3 x 3 images provide good sensitivity and specificity for monitoring subretinal and intraretinal fluid volume, and the full-field approach increases visual quality. "The design is also very simple, needing only a standard light source – rather than swept-source – and a regular, low-cost USB camera."

Though the team are still in the research phase, they have tested their device – alongside spectral-domain (SD)-OCT – in 10 patients with retinal disease (including AMD and retinal vein occlusion), and have shown that it can acquire clinically-useful images (Figure 1). "Even though the image quality is not quite as good as clinical OCT systems, the subretinal fluid does demark very well and the need for re-treatment is apparent," says von der Burchard.

The team plans to continue developing their device, and study its imaging capabilities in more patients by asking clinicians to grade both full-field OCT and SD-OCT images (while being masked), and compare their image quality, which biomarkers are present, and whether the patient needs anti-VEGF retreatment. "We believe that a hand-held OCT device would have a huge impact on alleviate disease burden, and may represent a paradigm shift in the treatment of wet AMD and other diseases."

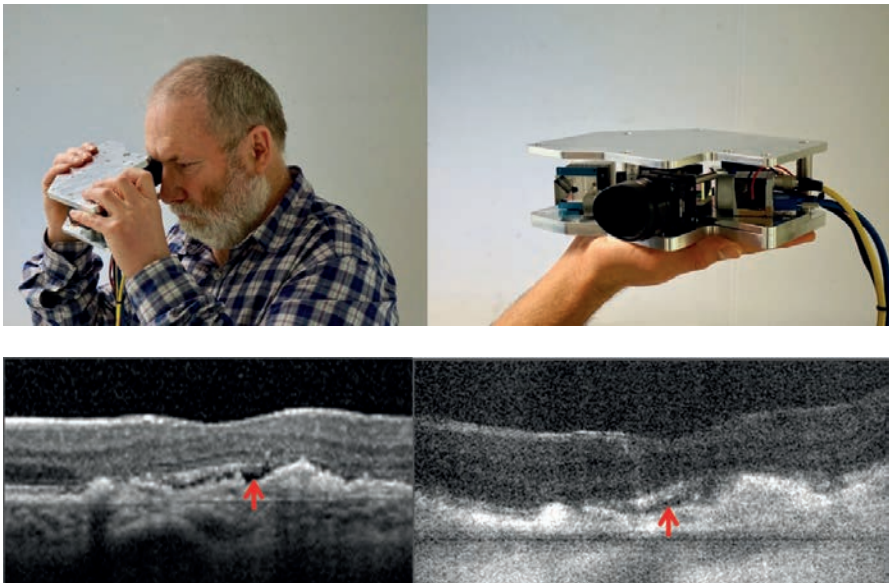

Figure 1. a. SD-OCT image (left) and off-axis full-field time domain OCT image (right) from a patient with AMD (84 years old; visual acuity, 20/80). The red arrow depicts subretinal fluid which is visible on images from both the clinical and hand-held device. b. The current prototype for the hand-held device. Credit: Universitätsklinikum Schleswig-Holstein, Kiel, and Medical Laser Center, Lübeck, Germany.

Reference

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Fresher and CRISPR

The promise of genome editing is tempered for genetically heterogenous diseases. Could a new approach overcome current limitations of correcting one gene per therapy, at least for rhodopsin-dependent retinitis pigmentosa?

As the basis of 'genome editing,' CRISPR (clustered regularly interspaced short palindromic repeats) and CRISPR-associated systems (Cas) are attracting intense interest. In CRISPR-Cas gene modification, a guide RNA (gRNA) directs nuclease to recognize and cut a matching DNA sequence (for example, an unwanted mutation). At the same time, a replacement (therapeutic) DNA sequence is provided for the DNA repair machinery to insert at the break site.

Part of the strength of CRISPR-Cas is its specificity – but this is also its weakness. Consider a disease arising from any one of many mutations in a given gene: conventional genome editing would require multiple therapies to be developed, trialed, approved and marketed for each mutation. Retinitis pigmentosa (RP) is a prime example: over 150 mutations are involved in the rhodopsin-dependent form of the disease. Even if a disease is relatively common – which RP is not – each mutation may only represent a very small group of patients. The economics of drug development simply don't allow the development of expensive therapies for small populations. So is CRISPR-Cas doomed to fail in genetically heterogeneous disease?

Not necessarily: a team led by Stephen Tsang at the University of Columbia, New York, USA, have reported a potential new approach. Rather than correcting individual mutations in a defective gene, Tsang advocates 'destroying' all expression of the endogenous gene, while simultaneously providing cells with non-defective replacement sequences.

It makes sense – but can it make patients better? In mice, at least, the results are encouraging. Applying this 'ablate-and-replace' approach in two murine models of rhodopsin-dependent RP (1), subretinal injection of Tsang's therapy resulted in outer nuclear layers (ONLs) 17–36 percent thicker than controls (mice that had received therapeutic DNA without ablation of the dominant mutant *Rho* gene). Electroretinography data also showed the preservation of a and b waves was significantly improved ($P<0.001$) in treated mice compared with controls in both mouse models. This stabilization of retinal structure and function in two models of rhodopsin-dependent RP indicates that 'ablate-and-replace' may extend the promise of CRISPR-Cas to genetically heterogeneous disease. What might this mean for the future? Said Tsang: "Genome surgery is coming, and ophthalmology will see genome surgery before the rest of medicine" (2).

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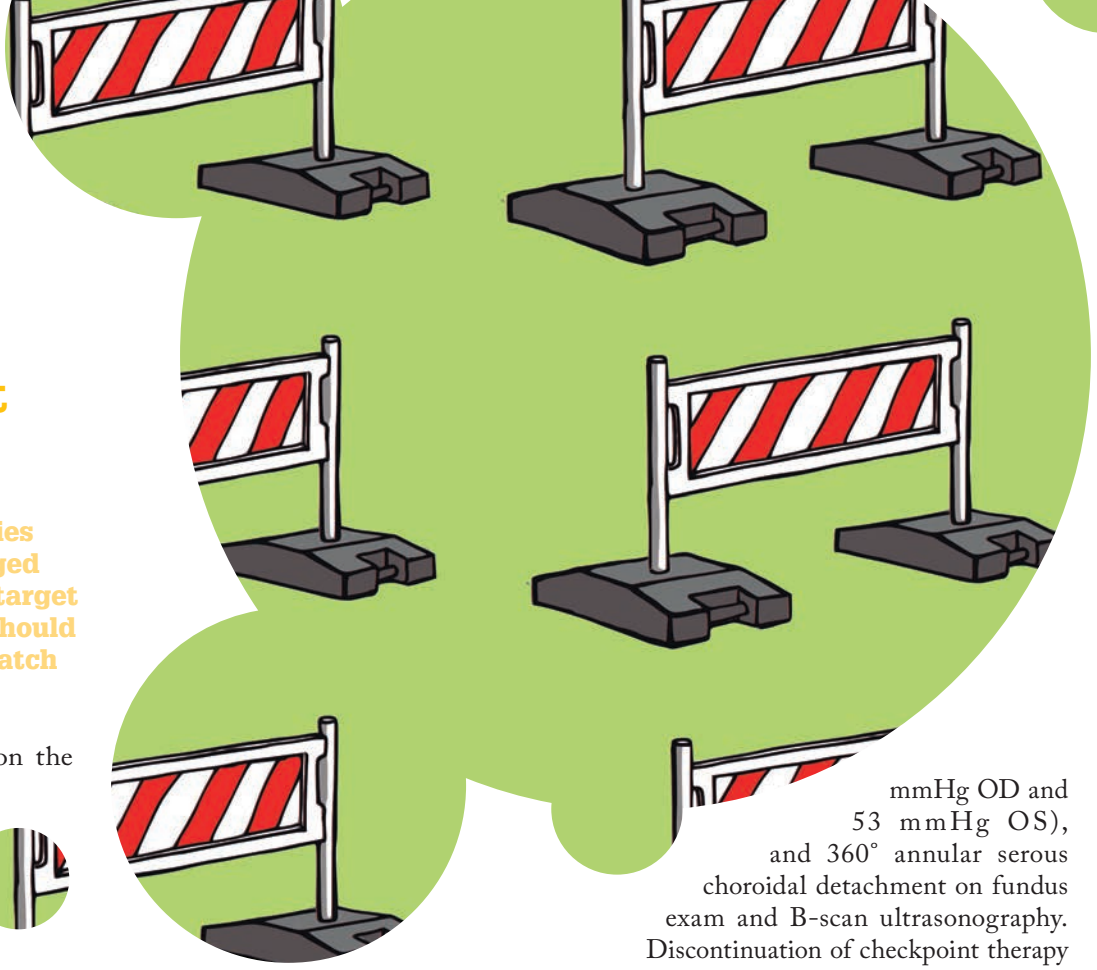

Check for Checkpoint Therapy

New immunotherapies have radically changed cancer care, but off-target effects exist. What should ophthalmologists watch out for?

If you've kept an eye on the oncology field, you'll know that checkpoint therapies are shaking it up. These drugs intercede key interactions between immune cells and their environment, facilitating a vigorous immune response. For example, PD-1 antibodies block inhibitory ligand interactions with the PD-1 receptor on T cells, keeping the cellular arm of the immune system stimulated. In oncology, this matters: firstly, because the immune system is far more effective at clearing disseminated disease than any drug; and secondly, because tumors are adept at usurping mechanisms of immune inhibition (many tumors express PD-1 ligand to depress T-cell function).

But therapies that turbocharge the immune system can also have some off-target consequences; some immunotherapy patients develop inflammation of the skin, endocrine or gastrointestinal systems. Might some adverse effects manifest in the eye? It seems so: a team from the University of Michigan Kellogg Eye Centre, Ann Arbor, MI, USA, have reported three cases where significant ocular symptoms were associated with checkpoint inhibitor therapy (1). Hakan Demirci, corresponding author on the paper, said: "We noticed large uveal effusions. In addition, there was anterior chamber inflammation in two of our patients" (2). And the uveal effusions happened suspiciously quickly: one to three months after commencing treatment, according to Merina Thomas, senior vitreoretinal fellow at Kellogg Eye Center and first author on the paper (2). Furthermore, in the two patients who discontinued therapy, the effusion resolved within 12 weeks; in the patient who continued the therapy, it persisted. So what did these three cases actually look like?

Case 1: Visual acuity (VA) at presentation, 20/25 OD and 20/150 OS; exudative retinal detachment and retinal hemorrhage apparent on fundus exam; 360° serous choroidal detachment visible by B-scan ultrasonography; and subretinal fluid visible by SD-OCT. Discontinuation of checkpoint therapy resulted in visual improvement (20/40 OS), and complete resolution of choroidal effusion and subretinal fluid.

Case 2: VA at presentation, 20/100 OD and 20/40 OS; elevated IOP (38 mmHg OD and 53 mmHg OS), and 360° annular serous choroidal detachment on fundus exam and B-scan ultrasonography. Discontinuation of checkpoint therapy resulted in improvements in choroidal detachment; decreased IOP (15 mmHg OD, 25 mmHg OS); and improved vision (20/60 OD, 20/30 OS).

Case 3: VA at presentation, 20/20 OD and 20/200 OS; periorbital swelling of left eye; serous choroidal detachment visible by fundus exam; and bullous choroidal detachment visible by B-scan ultrasonography. This patient continued therapy.

The upshot? Although ocular toxicities are relatively uncommon in checkpoint therapy, the authors point out that high levels of PD-1 ligand are found in many ocular tissues, and recommend that: "ocular toxicity, including uveal effusion, should be considered when evaluating patients taking PD-1 checkpoint inhibitors" (1).

References

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Taking Next Steps

Introducing the recipient of the inaugural ICO-Allergan Advanced Research Fellowship

Many of you will be familiar with the International Council of Ophthalmology (ICO) fellowships that support promising young ophthalmologists from low-resource countries with international training. In 2018, the ICO – in partnership with Allergan – also offered a new opportunity: the ICO-Allergan Advanced Research Fellowship. Open to young clinician researchers from all countries, this $50,000 award supports the recipient in continuing their research at an institute of their choice for one year. An esteemed judging panel of clinicians met at the ARVO 2018 meeting in Honolulu, Hawaii, to consider the applications, and selected Emilio de Almeida Torres Netto as the recipient of this inaugural fellowship.

"It was a unanimous decision," says Berthold Seitz, Director of the Department of Ophthalmology at Saarland University Medical Center, Homburg/Saar, Germany, and Director of ICO Fellowships. "Torres Netto truly fulfilled all the criteria; he has published extensively in the field, has numerous conference contributions, and has an excellent research project in keratoconus and corneal crosslinking (CXL)."

Torres Netto is currently completing a PhD and Research Fellowship at the Federal University of São Paulo, Brazil, in association with the University of Zurich, Switzerland. He is currently working with his co-tutor and clinical mentor, Farhad Hafezi, on factors influencing the biomechanics of corneal tissue. "It is amazing. I am so thankful to the ICO for this opportunity and to Allergan for supporting it," says Torres Netto. "I was very happy to find this Fellowship as it is exactly what I need to continue my research." His aims include investigating the optimal energy dose/irradiation time relationship to maximize oxygen re-diffusion in CXL, effects of temperature on the CXL procedure, as well as changes in corneal biomechanics due to heavy and repetitive eye rubbing. As well as improving CXL and refractive surgery, Torres Netto is also interested in improving crosslinking technologies for low income countries, and is currently involved in a trial studying PACK-CXL for the treatment of infectious keratitis.

Emilio de Almeida Torres Netto with Berthold Seitz, Director of ICO Fellowships.

Anna Gallifant, Associate Vice President and Head of International Strategic Marketing, Eyecare, Allergan, says: "On behalf of everyone at Allergan, I'm delighted to extend our sincerest congratulations to Dr. Torres Netto. The ICO mission to enhance ophthalmic education and international eyecare echoes that of Allergan's, and we are proud to partner with them to support their fellowship program and clinician-led research that will help set the standard for innovation and excellence in ophthalmic care."

Torres Netto will formally receive his award at the upcoming World Ophthalmology Congress (June 16–19, Barcelona, Spain), as well as deliver a presentation on his research.

In My View

In this opinion section, experts from across the world share a single strongly-held view or key idea.

Submissions are welcome. Articles should be short, focused, personal and passionate, and may deal with any aspect of ophthalmology. They can be up to 600 words in length and written in the first person.

Contact the editor at edit@theophthalmologist.com

On What You See, and What You Become: #Motivation

Wouldn't it be great to have more women recognized on The Ophthalmologist Power List?

By Imane Tarib, ophthalmology resident, Military Hospital Mohammed V-Rabat, Morocco

From a young age, I have looked up to people who excel in their respective fields. There is something powerful about having a role model; watching someone achieve your own aspiration makes it feel palpable – and, therefore, it's easier to follow in their footsteps. My role model was Dr. Aamer. I was 12 years old when he offered me the opportunity to attend a surgery for the first time. I still vividly remember my fast heartbeats while, standing on a ladder in a baggy scrub, I stood on my tiptoes to have a closer look. I eagerly followed every step in awe. The perfectly orchestrated flow of the surgery and OR environment made me realize that I was committed to achieving the same goal. When I stepped down from that ladder, I wasn't dreaming of being a surgeon, I was planning to become one. I joined medical school five years later.

After obtaining my MD degree, I stayed true to what I promised myself at 12, and decided to enter ophthalmology. As I started my residency, the field and the people I encountered fascinated me; keen to share my knowledge and learn from my ophthalmology peers across the world, I was active on social media. Attending the 2016 AAO meeting in Chicago allowed me to expand my network and meet many inspiring ophthalmologists – names and faces, and their work – started to feel familiar. Yet, I was subconsciously looking for my new compass – my "guiding star" in the ophthalmology community.

The day I came across The Ophthalmologist Power List, I rejoiced. I didn't get a guiding star but rather a galaxy. It was in 2016, and it felt like the Oscars of Ophthalmology! I remember how much I enjoyed scrolling through the names and discovering how they each contributed to advancing our field. Recently, I have had the privilege to work closely with one of these 'stars'. Working under Florian Kretz's mentorship has set new standards of excellence for me, and when the 2018 Power List came out, I was extremely proud to see his face featured. However, scrolling through the list I couldn't help noticing that amongst dozens and dozens of profiles, women were quasi absent. The visual person that I am, I used my lunch break to quickly draw a graph and my assumption was true. Only 13 percent of the ophthalmologists on the list – and thus in leadership positions – were women: this was an awakening to me. What kind of message does that send to a female ophthalmology resident who aspires to lead in her field? Answer hint: the road is not paved. Though the increased number of female residents creates the illusion ophthalmology is getting close to achieving gender parity, that 13 percent reminds us of the truth. Across various fields, it is not easy to lead as a woman. Yet, the 12-year-old me refuses to accept this fact!

As ophthalmologists, we have chosen to dedicate our life to making sure that people see. Though gender parity is an issue across many industries, I believe that we as ophthalmologists have a prime role not only in helping people have healthy

vision, but also a healthy visualization of what women can achieve in leadership roles. Visualization matters to all the 12 year olds out there who, like me, wanted to see someone like them achieve their dearest dreams. So while everyone is busy discussing gender parity in the Oscars, I think there is an equal sense of urgency for it in ophthalmology leadership. After all, no one would have been able to see disparity at the Oscars without a healthy pair of eyes!

Rebuilding the Niche

MSCs are a viable option for the management of LSCD, and should be pursued in carefully designed clinical trials

By Medi Eslani, University of Illinois at Chicago; Peiman Hematti, University of Wisconsin-Madison School of Medicine and Public Health, Madison, WI, and Ali Djalilian, University of Illinois at Chicago, IL, USA

Limbal stem cell deficiency (LSCD) arises from many etiologies, including traumatic or toxic (e.g. contact lenses, chemical/thermal injuries), inflammatory (Stevens-Johnson syndrome, mucous membrane pemphigoid, chronic allergic diseases), and congenital (aniridia). Clinical manifestations include corneal conjunctivalization, non-healing epithelial defects, neovascularization, scarring, and severe pain and loss of vision (1). In all cases, irrespective of etiology, a key feature is the loss of the limbal niche. Currently, LCSD is managed by surgical transplantation procedures including conjunctival limbal autograft (CLAU), cultivated limbal epithelial transplantation (CLET) and simple limbal epithelial transplantation (SLET). These cutting-edge techniques are more appropriate for unilateral disease. For bilateral cases of LCSD, limbal allograft techniques prevail. We propose that all LSCD treatments should focus on rebuilding the limbal niche to restore stem cell function, and we believe that mesenchymal stem/stromal cells (MSCs) are a promising solution.

Limbal epithelial stem cells (LESCs) reside in the Palisades of Vogt, where they closely interact with extracellular matrix components, melanocytes, immune cells, blood vessels, nerves and MSCs. Of these, MSCs have a major regulatory role in niche biology, and help maintain the 'stemness' of the LESCs (2, 3). Given their critical function, MSCs are ideally positioned for "niche regeneration"; they secrete various growth factors and cytokines that promote epithelialization and wound healing, and exhibit anti-inflammatory anti-scarring, anti-angiogenic and neurotrophic properties (3). Different experimental models have shown MSC transplantation successfully reconstructs damaged corneal surface; they promote wound healing by differentiation, proliferation, and secretion of trophic factors to revitalize remaining LESCs. This ability to support regeneration of the damaged ocular surface has been shown for MSCs isolated from various tissues (cornea, bone marrow, adipose tissue, umbilical cord and perinatal), and thus appears to be a general property of these cells.

Inflammation is also a major cause of niche disturbance in LSCD. MSCs can modulate both innate (neutrophils and macrophages) and adaptive immune cells (including T cells, B cells and natural killer cells). These immunomodulatory properties of MSCs suppress local inflammation, protecting LESCs in their niche. We have recently shown MSCs directly inhibit corneal neovascularization, and modulate infiltrated inflammatory macrophages toward an anti-inflammatory anti-angiogenic immunophenotype, which further potentiates MSC properties (4, 5).

Currently, there are several clinical trials evaluating MSCs. A recent randomized clinical trial compared MSC-therapy with CLET, and found that both procedures were equally effective at restoring corneal epithelial function (6). The authors concluded that, as LSCD treatment with MSCs is more efficient than CLET in terms of patient morbidity, time- and resource-consumption, and economic expenditure, MSC translation into clinical practice should be pursued.

We believe that MSCs may provide a distinct strategy for restoring the health of the limbal niche, without the need for costly procedures, such as CLET, or invasive surgery. Future clinical studies are needed to further define their precise role in the management of severe ocular surface disease, but we hope to see MSC-mediated therapy for LCSD enter the clinic one day.

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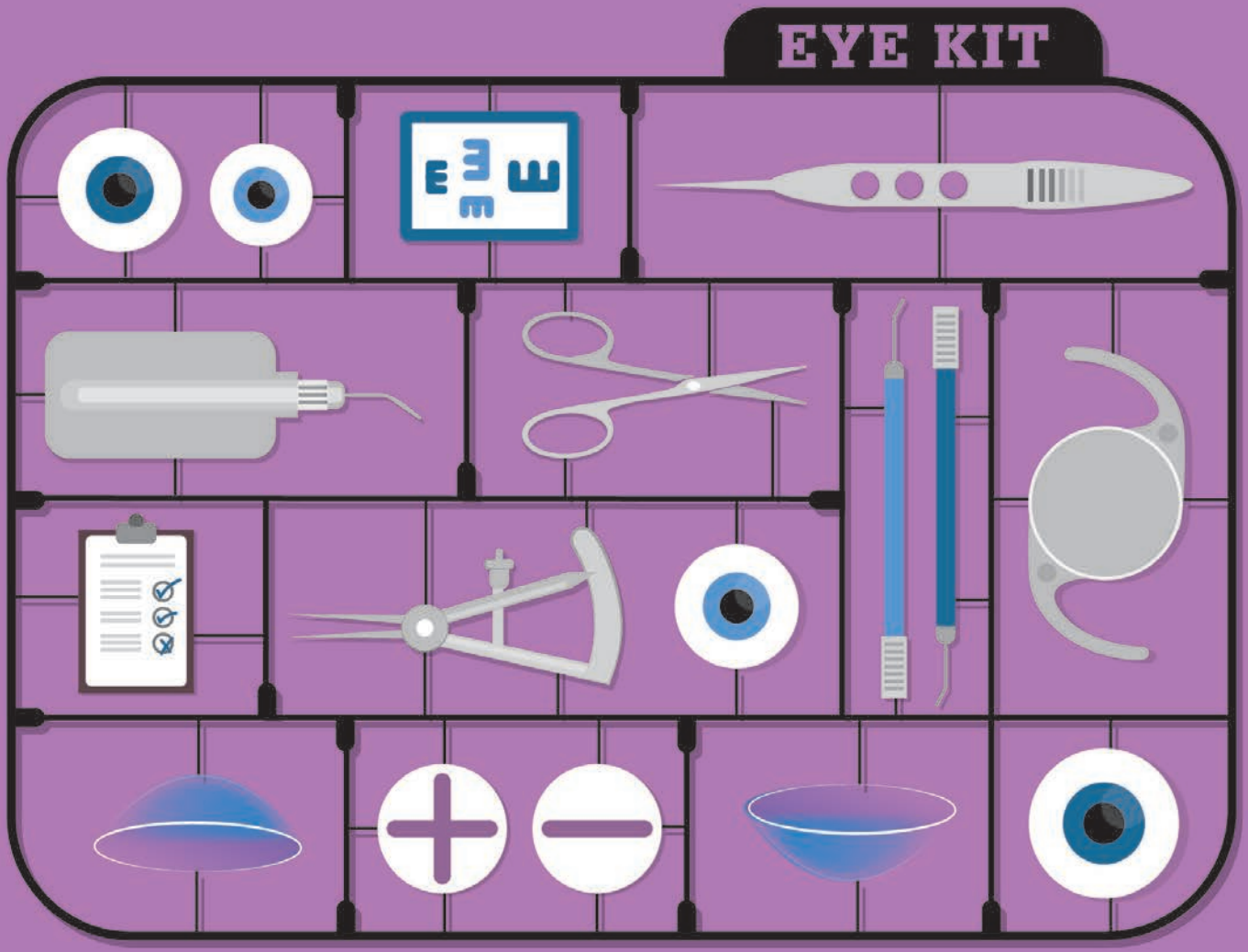

EYE KIT

MODEL SURGERY

How 'rusty' cataract surgery skills led to game-changing surgical training models

By Stuart Stoll

I never planned to create a business with ophthalmic surgery training models – the SimulEYE line of ophthalmic surgical training models happened almost by accident. In fact, it started as a hobby, but when I found that I had a knack for modeling, it became a passion. And when I saw how people reacted to the models, and how much they were appreciated, I began to get a real joy out of it. Nevertheless, turning a hobby into a business has been challenging; obligations to my practice and my family always came first, but InsEYEt (the LLC behind SimulEYE) took up any other time that I wasn't sleeping... Now, the company has taken on a life of its own, and all I can do is hold on tight and see where the ride takes me!

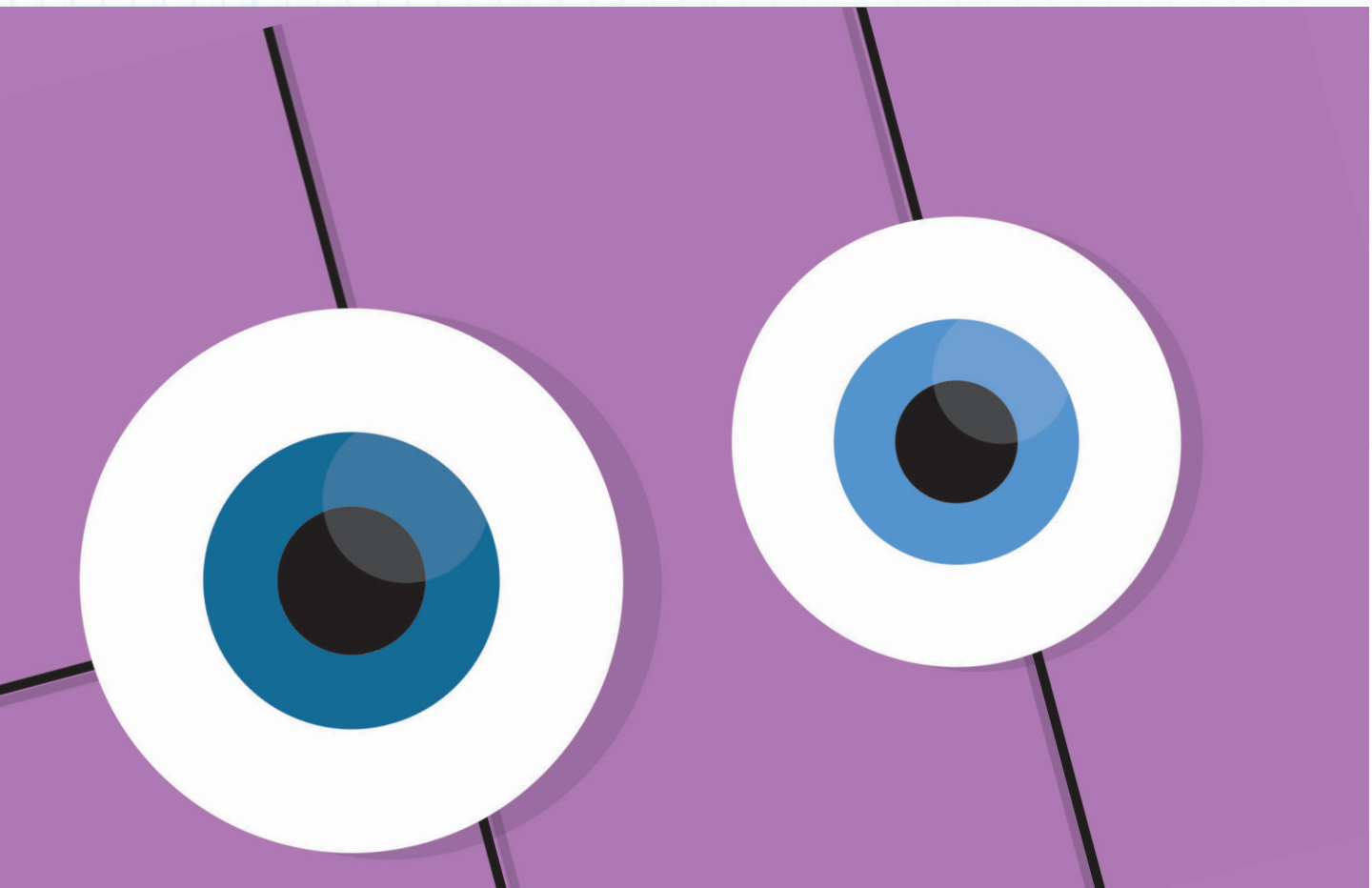
MOTHER OF INVENTION

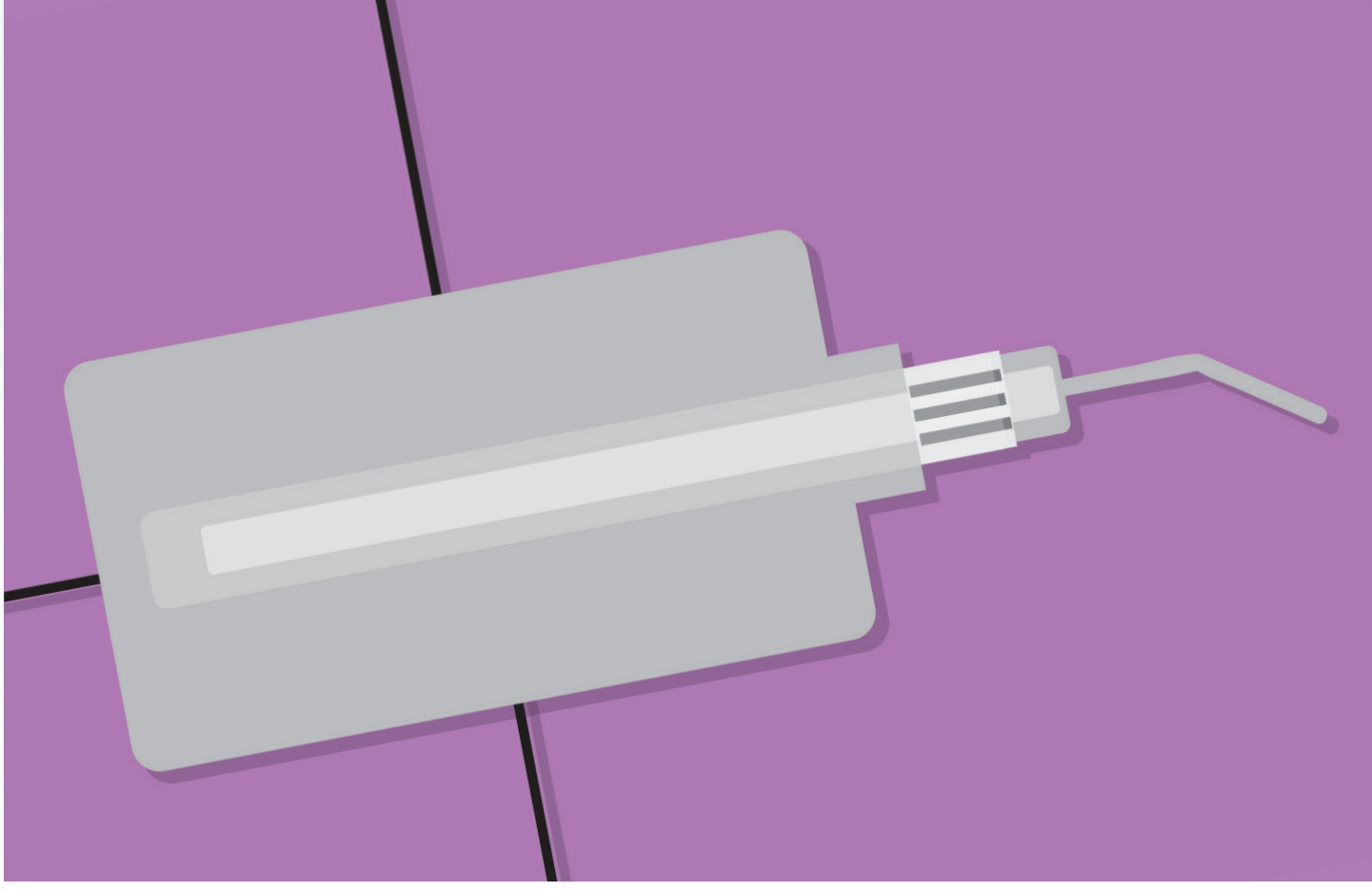
It all began when I took time out of hands-on surgery during my LASIK-only residency with Dr. Howard Gimbel in Canada. The Canadian government allotted all cataracts to Canadian surgeons, and so, although I learned a tremendous amount from watching Howard, I couldn't actually do any cataracts myself. In fact, I didn't perform cataract surgery for a year, so when I returned to Beverly Hills in 2001, I struggled with some of the steps of cataract surgery, particularly the continuous curvilinear capsulorhexis (CCC) technique. I knew I needed to practice and refine my competencies – and fast. But how?

At first, it seemed there was no quick way to make my life easier. I'd found some suitable plastic film, but couldn't see how to mount it under tension to make an acceptable model of the eye. One day, however, when I was checking out of a store, I saw some silly putty on the shelf – and that was the 'aha' moment! I took the putty home, and discovered that by wrapping the film around it and squeezing I could make it as dome-shaped as I needed. Furthermore, I could cause the tear to run out and practice rescuing the CCC. Doing multiple practice sessions with this model before surgeries helped me very quickly regain my skills. I didn't know it at the time, but that simple prototype was the basis of the SimulEYE models.

A couple of years later, at the ASCRS meeting in 2005, I presented a video of my model. I wasn't trying to sell it – I just wanted to make it available to residents to benefit them and their patients. But I found that residents weren't interested in making models; they wanted an off-the-shelf kit. So I made one. Next question: how to distribute it? I showed it to some of the bigger companies, and they loved it – but not always in the way I expected. For example, the head of Bausch and Lomb said, "This is a million dollar idea, but we're not interested." He thought I was trying to sell him the entire concept, when I just wanted him to buy the kits from me and distribute them to residents. In any case, those discussions were torpedoed by the Sunshine Act, which prevented pharma from giving out freebies. Even free pens were off-limits, so my surgical training models were definitely not going to reach end-users by that route.

"I found that residents weren't interested in making models; they wanted an off-the-shelf kit. So I made one."





"Making a new model eye isn't easy [...] I tried all kinds of things – sprinklers, door-stops, pot magnets..."

It was a frustrating time. Maintaining patents is a costly process, and I couldn't help wondering if it was all worth it. But then I got an email from a company called Truevision 3D. The folks there had seen my patents, and wanted to use my system to demonstrate their technology at trade shows. Truevision was located in Santa Barbara at the time, only an hour away from my house, so I went to see them. It turned out that they needed a model eye to go under their 3D video scope. I said that the hand-held model I had developed wouldn't be adequate for their purposes (way too amateurish for doctors!), but I'd help them if I could. However, making a new model eye isn't easy, so I spent days searching hardware stores for parts that I could use to improve the existing device. I tried all kinds of things – sprinklers, door-stops, pot magnets – and eventually constructed something that had enough weight for stability and that could hold the film under tension. And Truevision loved it!

After that, things really started taking off. Truevision would demonstrate their videoscope at trade shows, people would ask where they got the model eye, and I would get call after call. So I formed insEYEt, LLC, to deal with the demand. We started with SimuloRhexis (Figure 1), a model for CCC training, which has evolved tremendously over time. One of the first people to try it was Kevin Miller, who runs a wet lab course for UCLA residents. And soon he was asking for other models; one time, he asked for a YAG capsulotomy training model to support Lumenis demonstrations – only three months before the course started! I said I would do it, even though I had no idea how. And I did, although it was a real scramble.

NEW MODEL ARMY

From there, more and more opportunities came along, and I developed model after model. At InsEYEt, we coined the name SimulEYE to cover our growing range – models not just for rhexis, but for YAG (Figure 2), for laser peripheral iridotomy (LPI; Figure 3), for selective laser trabeculoplasty (SLT; Figure 4), and so on. Today, we have 16 models, four

Figure 1. The first of many: an early SimuloRehxis kit (left); the current model is shown on the right. This model was developed for capsulorhexis training, and permits corneal incisions, viscoelastic injection into the anterior chamber, and creation of a CCC. The pressure behind the capsule can be raised to increase the difficulty of the procedure.

Figure 2. SimulEYE YAG provides a corneal-scleral shell for use with or without a YAG capsulotomy laser lens. Inside is an iris, anterior capsule membrane, an IOL and a posterior capsule that will respond to Nd:YAG laser treatment.

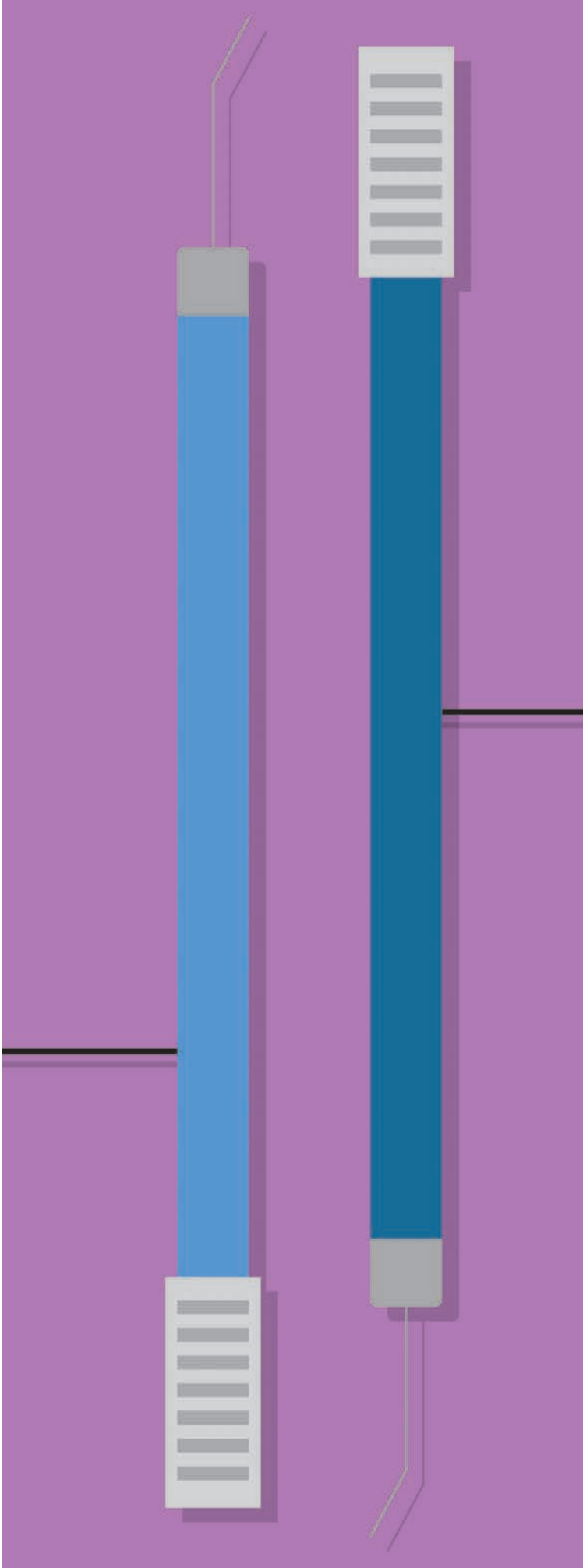
Figure 3. SimulEYE LPI provides a corneal-scleral shell for use with or without an iridotomy lens. Inside is an iris with four treatment areas. Multiple laser spots need to be delivered in focus to break through the iris and create the peripheral iridotomy.

"The YAG laser models are very important – I've had residents on their first laser operation ask me things like what settings to use! You really shouldn't be asking those kinds of questions with a patient seated at the laser."

of which are for MIGS training. But SimuloRhexis was our first model, and it remains fundamental – all residents should use this. The YAG laser models for SLT and LPI are also very important; I know this from experience, because I've had residents on their first laser operation ask me things like what settings to use, and how to change the power! You really shouldn't be asking those kinds of questions when you have a patient seated at the laser.

Our training model for ring implants was also a very significant product innovation. We started working with MicroSurgical Technology (MST) about four years ago. I'd made a prototype model for Malyugin ring implant training, and showed it to the rep at the MST booth. She immediately pointed to the guy next to her –who turned out to be Larry Laks, the head of MST! And now all the MST reps have a Small Pupil SimulEYE (Figure 5) for teaching Malyugin ring procedures. The model helps MST to train doctors properly, and that helps prevent complications, such as intraoperative floppy iris syndrome, which can arose from medications like Flomax.

The next additions to our portfolio included the SimulEYE Femto model for Alcon LenSx training. The impetus for this product came from my LenSx training session, as the model eye we used was a complete horror show – completely unrealistic scanning and docking. I knew I could do a better job, so I made



NUTS, BOLTS, SUCTION CUPS AND COSTS

Making a new SimulEYE mostly involves finding new materials and trying them out; I may not have an engineering background, but I think I now have a Master's in trial and error! It also helps to be a practicing ophthalmologist, as knowing how ocular tissues look and feel is invaluable when you are modeling them. Even so, SimulEYE development was awkward at first; I didn't even have a standard housing to hold the different components of a model – instead, I'd pay 50 cents at a candy machine and use the container as a housing. But things have gotten much easier over time. Today, we have molds for the housing and other standard components, and that has really accelerated the development of the SimulEYE portfolio.

The housing and the externals are very similar for all of our models; for example, they all use the suction-cup base, because it both confers stability and permits eye movements in a self-supporting platform which does not require a head model. The models mainly differ with regard to the interior – the iris plane, the materials used, whether we have a flexible iris, whether we have a capsular bag, whether we use gels or simulated vitreous, and so on. We outsource housing manufacture, but the internal parts are fabricated in-house and then put into each model manually. At present, we 3D-print our prototypes in the initial design phases, but use steel injection molds for the final products; however, our manufacturing model may incorporate 3D-printing in the future, if it improves. We're keeping an eye out (no pun intended) for technology developments, and we will change our manufacturing process, if it becomes appropriate to do so.

In all cases, we ensure manufacturing costs are controlled. And that's how we can sell models, such as the LenSx SimulEYE, for only $40! Even our higher-priced eyes are extraordinarily good value: thus, the ABiC iTrack (Figure 8) is priced at $200, because the incorporation of channels makes it a more complex item; however, it can be used multiple times, so it still works out at about $40 per procedure. We've always tried to find a balance between the price for our corporate partners and one that would be affordable to residents with limited budgets.

Figure 4. SimulEYE SLT provides a corneal-scleral shell for use with an SLT laser lens. Inside is an iris and a pigmented angle structure that will depigment upon application of SLT laser treatment. 'Champagne bubbles' form with each pulse and increase as the energy is increased.

Figure 5. SimulEYE Small Pupil was developed for use with iris expansion devices, such as the Malyugin ring, to learn aspects of insertion and removal of the device. The model may also be used for placing iris hooks or for practicing IOL cutting and removal in the anterior chamber.

Figure 6. SimulEYE Aphakia provides an empty capsular bag with a pre-made 5.5 mm capsulotomy, and is ideal for implanting IOLs and for working with CTRs and capsule hooks.

some prototypes and then met up with the LensX engineers and showed them what I'd done. They loved the concept, and realized they needed something better than they had and that I could give it to them. So I developed the prototypes into a LenSx eye – but just as I finished the model, they introduced laser autoregistration! Obviously, they weren't going to re-write their software to match my SimulEYE model; I would have to make my model compatible with their software. Consequently, I went back to the drawing board, and we modified our materials to fool the laser so that the autoregistration features would work. The end result was a LenSx model that you can dock and scan, where everything auto-registers and you can use the software as normal. Furthermore, you can hit the button and see an actual treatment happening – bubble patterns, capsulotomy, lens fragmentation, corneal incisions – all in one model!

EYE SPY

The Ophthalmologist overheard Steve Safran talking with Stuart Stoll at Cataract Surgery: Telling It Like It Is 2018.

"Thank you very much for making this event a success. Your simulated eye is a fantastic model and showed itself as such today [...] I didn't have a model in mind when I moved towards doing a wet-lab. Then somebody gave me a SimulEYE that they'd received from a course they'd taken. I played with it and liked what I saw."

Stoll's reaction? "We get these kinds of endorsements all the time! But hearing positive feedback is really rewarding – when a well-known ophthalmologist gets excited about your product, you know you've done well."

"Some products in the pipeline have come out of our collaborations with top ophthalmologists."

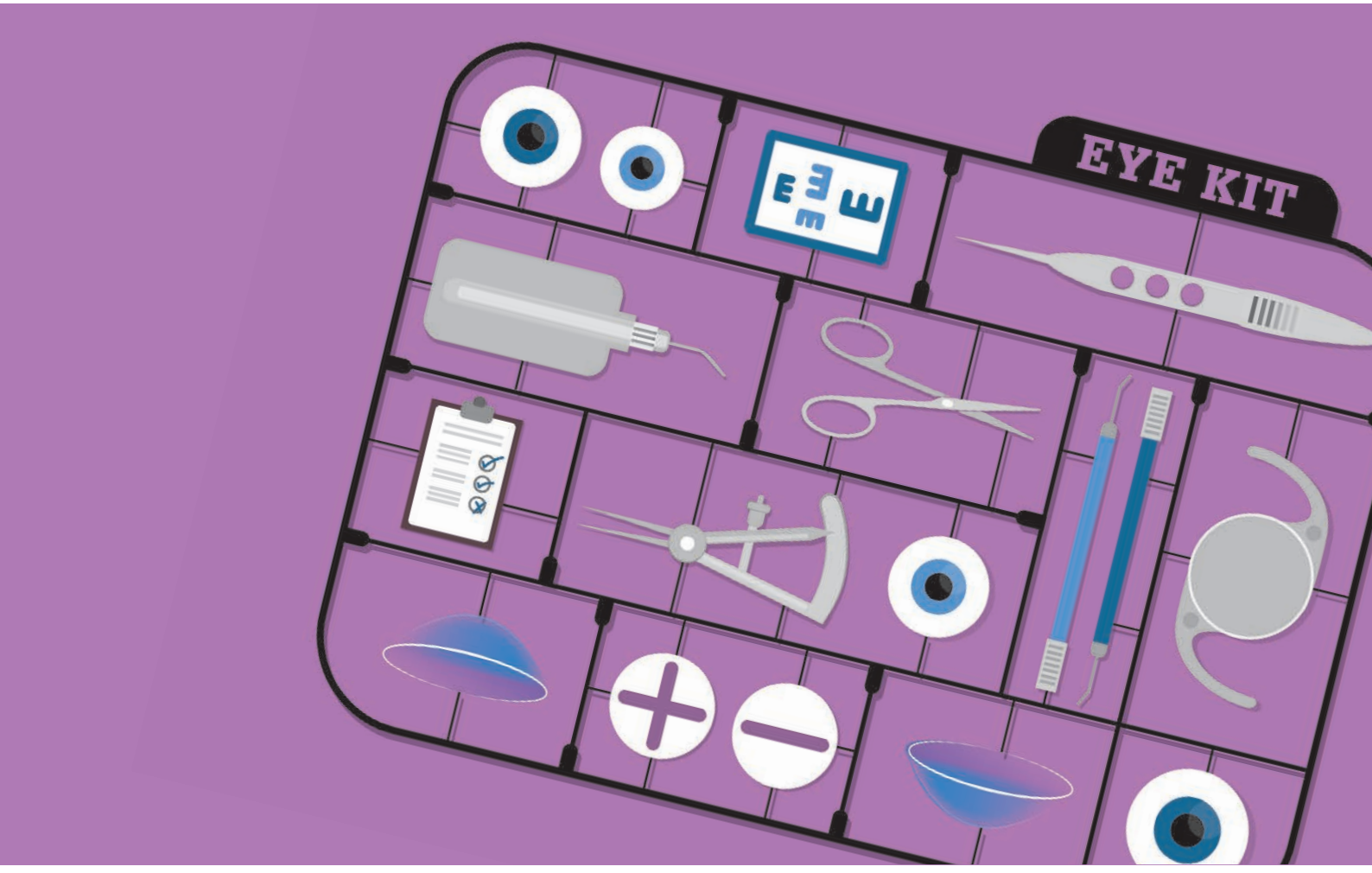
With the momentum of the SimulEYE Femto sales, I rented a commercial facility, and InsEYEt really started moving. The SimulEYE Femto isn't our only model popular with industry; many others have proved tremendously helpful for companies selling products in their respective fields. For example, when Alcon re-launched the Ultrasert preloaded injector, all their reps used our Aphakia model (Figure 6) to demonstrate Ultrasert lens delivery. In fact, at the AAO meeting in 2017, I got talking to a rep who was using our Aphakia eye model, and when he realized that I was the one who developed it, he lit up and told me how much the sales team loved it. I get that all the time!

MODELING THE FUTURE

We're continuing to develop new models and materials. A great example is our new synthetic vitreous – staining and vitrectomy can be performed, and it moves differently depending on whether it is being cut or pulled during aspiration. We are also creating a model that mimics weak zonules; you can use it to practice inserting Ahmed ring segments and CTRs. For developing world markets, we're considering making models to support training for small incision cataract surgery (SICS).

Some products in the pipeline have come out of our collaborations with top ophthalmologists who have asked us to build specific models for them. For example, we have developed an iris prosthesis model for Dr. Michael Snyder. Other pipeline projects have come from our relationship with industry: companies now know that if they share their new product plans with me in good time, I can have a new model and training program all ready for their product launch. It's good for everyone to have those conversations at a relatively early stage.

In the near term, I expect the SimulEYE range to replace the porcine and bovine eyes that universities typically rely on to train ophthalmology residents. People think animal eyes



are cheap and convenient, but that's not really the case. For example, you can't obtain pig eyes whenever you want because they are harvested on particular days (and if they sit around they go bad pretty quickly), and there are shipping and storage costs too. But their biggest limitation? They are actually not good models of human eyes: the size is wrong, the capsule is wrong, you can't put an iris ring in, and so on. In my opinion, the porcine/bovine approach is outdated – SimulEYEs look to the future! In the longer term, there will always be new technology coming through, and always a need for tools to train surgeons in that new technology. Nobody wants their first time experience to be on an actual patient. Consider the Yamane intrascleral haptic fixation technique; there are so many things to get right, paracentesis positioning, haptic docking, and so on.

In summary, the idea behind SimulEYE is not to exactly replicate human tissue, but to help surgeons – and patients – avoid complications. We do this by providing a uniform simulation platform on which everyone can learn the same basic procedure, and from which they can evolve the idiosyncrasies of the technique that most suit them. Our models are a very cost-effective way of practicing or re-learning ophthalmic surgical techniques. I could never reach as many surgeons through one-to-one training as I can through developing a new SimulEYE.

Our motto is "Training Surgeons, Supporting Industry, Improving Outcomes," and I'm delighted to know that we're having a positive impact. Not only do we help train surgeons to achieve better outcomes, but we also help industry to get new technology out into the ophthalmic community. The end result is that we are making a difference for patient care. All in all, InsEYEt has been an amazing ride, and it continues to open unexpected doors and initiate conversations with people and companies that I couldn't have imagined. And I'm still just hanging on to the reins and seeing where the ride takes me!

Stuart Stoll is the Inventor and Founder of SimulEYE, and a cataract and refractive surgeon at Beverly Hills LASIK Center, CA, USA.

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Glaucoma Diagnosis: Measuring Up to Expectations

How can we use current imaging technologies to improve glaucoma diagnosis and follow-up – and, ultimately, patient care?

By Sanjay Asrani

Traditionally, glaucoma diagnosis has relied on subjective assessments of optic nerve head (ONH) damage and/or measurements of visual field loss by automated perimetry. Though automated perimetry may use more objective scoring systems and algorithms, these can be unreliable – especially in the earlier, asymptomatic stages of disease, where nerve fiber loss may not translate into a detectable impairment in visual function.

At a Glance

- *Current methods of glaucoma evaluation may fail patients in the early stage of the disease*
- *Application of OCT technology to measure multiple parameters improves the sensitivity and specificity of glaucoma diagnosis and monitoring*
- *In particular, measurement of the Bruch's membrane opening–minimum rim width (BMO-MRW) can provide a clear indication of glaucomatous tissue loss, especially when it corresponds with findings from other measurements*
- *Use of multiple modalities to assess multiple retinal substructures may therefore assist physicians in assessing challenging patients and borderline diagnoses.*

The "hit and miss" nature of glaucoma diagnosis results in many patients remaining unrecognized and, therefore, being deprived of vision-preserving treatments. Similarly, where diagnostic techniques are insufficiently sensitive to detect markers of disease progression, patients may not have their treatment appropriately modulated in response to advancing disease.

Imaging tools and techniques able to reliably detect early glaucoma or identify patients for treatment intensification would be of great benefit to patients and public health.

Diagnosing – the problem

Though it is simple to spot glaucoma in patients who present with classic signals of raised IOP, optic nerve cupping and typical visual field changes, difficulties arise when the combination of these signals does not concur; for example, when IOP and visual field measurements are normal, but the optic nerve cupping is suspicious. In these cases, ophthalmologists typically employ advanced imaging technology to clarify the situation.

The recognition that there was an unmet need for better glaucoma diagnosis (particularly in these challenging cases), resulted in a race to develop better imaging technologies – confocal scanning laser ophthalmoscopy, scanning laser polarimetry, and OCT. OCT is particularly useful, as it provides cross-sectional images of the ONH and macular inner retinal layers. Imaging of retinal ganglion cells (RGC) and their axons as they approach the ONH allows you to assess many parameters such as nerve fiber layer thickness and macular thickness that are highly relevant to glaucoma evaluation – the macula has the highest RGC concentration of all retinal areas, and so cell loss is more readily detectable in this region. OCT-based measurements can also assist differential diagnosis.

Other pathologies that can masquerade as glaucoma include brain tumors, strokes, and even aneurysms pressing on the optic tract – all of which are serious conditions needing urgent attention. In neurological abnormalities, the pattern of visual loss respects the vertical midline in both eyes – a clear pointer that additional investigations are required to rule out a neurological cause. Less serious conditions that may interfere with diagnosis include retinal scars in the periphery, vascular occlusions in the retina, a tilted optic nerve, or even epiretinal membranes (Figure 1).

However, there are still difficulties with OCT. Diagnoses can be missed because changes indicative of genuine glaucomatous damage to the optic nerve may be ascribed to "green disease" if the loss is focal or an artifact such as an epiretinal membrane hides the loss of tissue thickness. "Red disease" on the other hand is artifact-related OCT abnormalities in the absence of real glaucomatous damage. These misdiagnoses arise because normal anatomic variation in optic nerve structure is not yet fully reflected in the normative databases available to OCT devices. For example, highly myopic eyes often have atypical optic nerves – unusually sized, or associated with atypical features such as epiretinal membranes, tilted discs, peripapillary atrophy, or traction artifacts (Figure 2). Incorrect glaucoma diagnoses in these in patients leads to unnecessary medication or surgery, and the consequences can be lifelong; even if misdiagnosed patients present for a second opinion, it is difficult to suggest ceasing treatment because longitudinal records of IOP, OCT or visual field readings often are lacking, making it impossible to confirm or rule out disease progression. However, I firmly believe that over- or under-diagnosis can be avoided by employing multiple modalities to measure different anatomical features.

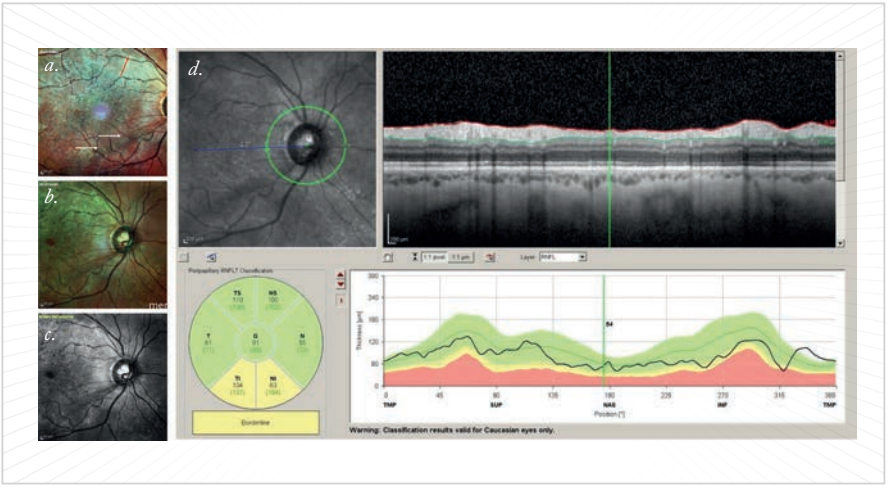

Figure 1. RNFL loss is easily visualized inferiorly along with early loss superiorly (red arrow in (a)) in multicolor images (a–c) in the presence of a dense epiretinal membrane. OCT of RNFL (d) shows early loss inferiorly but is unable to detect loss superiorly because of increased thickness caused by epiretinal membrane.

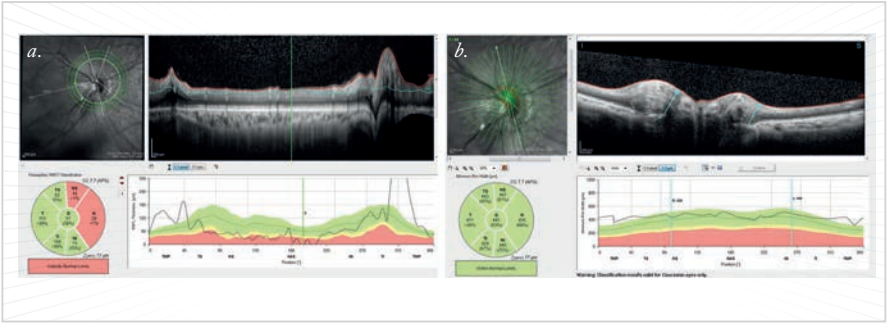

Figure 2. High myopia can make things challenging when it comes to diagnosing glaucoma: (a) shows many artifacts, whereas (b) shows a normal result.

The spectra of modalities and measurements

As OCT device resolution has improved over the years, it has allowed segmentation of individual layers and recognition of anatomical features, such as the Bruch membrane opening (BMO). Similarly, successive software modifications have extended OCT capabilities from measurement of retinal nerve fiber layer (RNFL) thickness to ONH evaluation – and now to segmentation of the macular inner retinal layers (for example, with Topcon's DRI-OCT Atlantis or Heidelberg Engineering's Spectralis). Such measurements allow automatic calculation of multiple modalities at once, such as RNFL thickness, the Bruch's membrane opening-minimum rim width (BMO-MRW – the thickness of the nerve tissue lining the optic canal), and macular thickness. Once artifacts are excluded, advanced OCT systems are very useful for monitoring stability in early and moderate glaucoma.

The BMO-MRW may be particularly useful for clarifying borderline abnormal results by helping confirm the presence or absence of RNFL abnormalities in the presence of surface pathologies, such as peripapillary epiretinal membranes

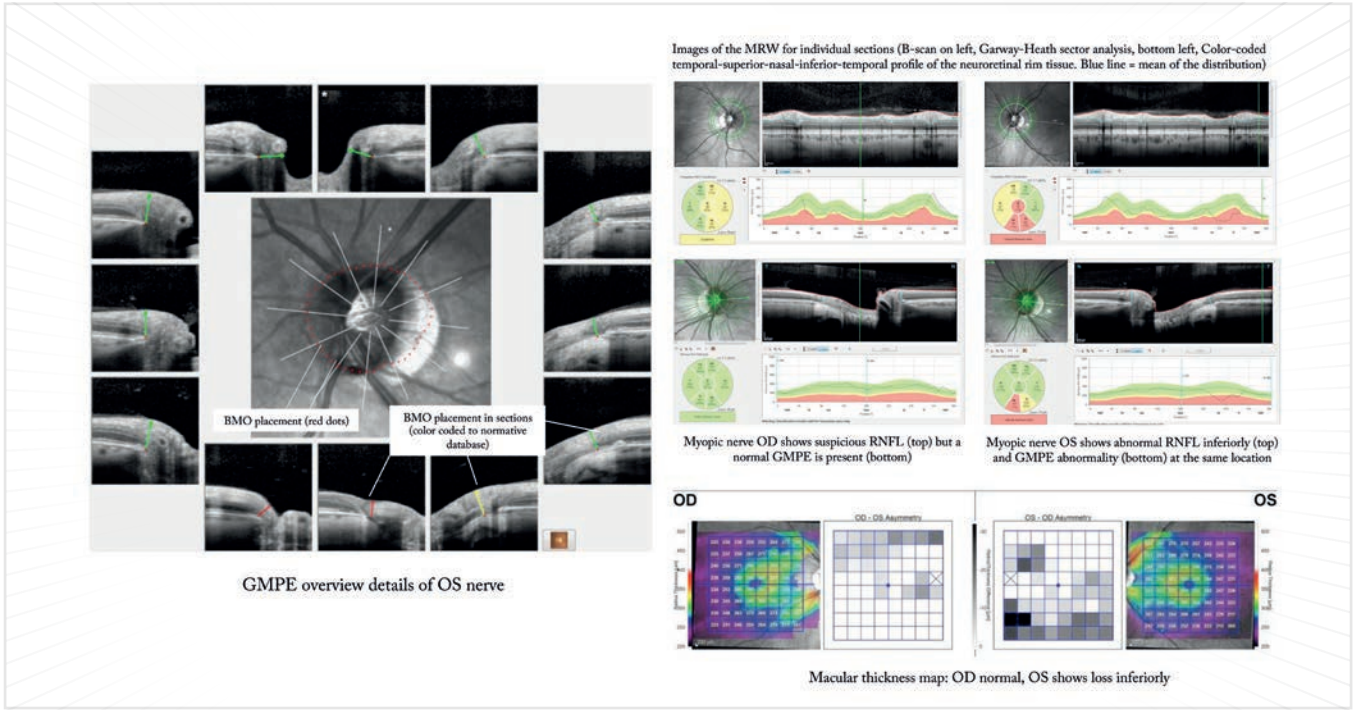

Figure 3. Assessing multiple modalities for more robust diagnostic outcomes in a high myope with a suspicious RNFL but normal GMPE. Myopic nerve OS shows abnormal RNFL inferiorly, and a GMPE abnormality is also visible at the same location. The macular thickness map (bottom, right) shows a normal OD, but loss inferiorly OS. BMO, Bruch's membrane opening; GMPE, glaucoma module premium edition; MRW, minimal rim width; RNFL, retinal nerve fiber layer.

(which distort RNFL thickness measurements, see Figure 3), or in patients with tilted myopic optic nerves and severe peripapillary atrophy. BMO-MRW is reported to be a better criterion for detecting early glaucoma than either circumpapillary RNFL thickness or Bruch membrane opening-horizontal rim width (BMO-HRW): at 95 percent specificity, the sensitivity was 81 percent, 70 percent and 51 percent for BMO-MRW, RNFL thickness and BMO-HRW respectively (1). In short, including BMO-MRW assessments should be beneficial for glaucoma diagnosis. It should be noted that in late glaucoma, tissue thickness is so minimal that RNFL and BMO-MRW measurements are of little value; however, macular thickness can still be used to monitor the disease state in these patients.

For analysis of BMO-MRW, normative databases only exist for the Heidelberg Spectralis OCT system. However, the Spectralis has no normative databases for the assessment of macular ganglion cells,– unlike Zeiss' Cirrus and the Optovue's RT-Vue. As ganglion cells – analysis can avoid artifacts arising where total retinal thickness is affected by non-glaucomatous disease, instruments with this capability have advantages over the Spectralis. However, though segmentation capabilities of various devices are improving, such software is still subject to significant errors. I also measure asymmetry between the eyes and hemispheres, which is offered on the Spectralis. The concept here is that the findings should correspond; for example, tissue loss indicated by RNFL and BMO-MRW measurements should match with a decrease in macular thickness and when compared with the other eye, the changes should be asymmetric as is typical of mild to moderate glaucoma. Such correspondence gives much more confidence in a glaucoma diagnosis; if the

"Correspondence of multiple modalities gives much more confidence in a glaucoma diagnosis."

"Arcuate RNFL loss can confirm very early glaucoma – even in the absence of classic signals."

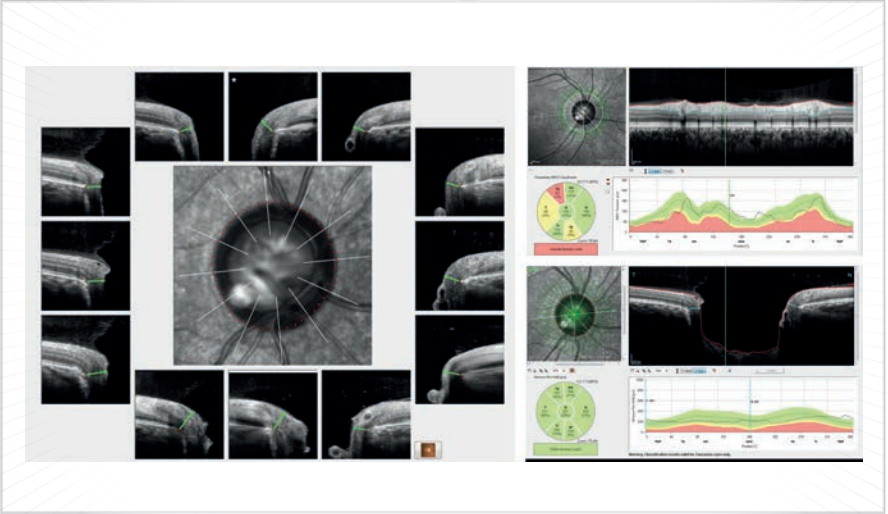

Figure 4. Borderline diagnoses. Large cup with an abnormal RNFL result (left) – glaucoma is suspected. GMPE (bottom) shows a normal result. BMO, Bruch's membrane opening; GMPE, glaucoma module premium edition; MRW, minimal rim width; RNFL, retinal nerve fiber layer.

Figure 5. Multicolor imaging shows up early RNFL loss in the presence of a normal cup

three do not correspond, it may well not be glaucoma (Figure 4).

The Spectralis machine is also unique in that it has the capability of multicolor, i.e., it can interrogate the retina with infrared, blue and green wavelengths, and then combine these three outputs to provide multicolor images of the fundus; the blue and green wavelengths depict the RNFL in exquisite detail. This modality combined with OCT can be very useful for early detection of RNFL loss (which is to say, before the peripapillary thickness has reduced to abnormal values; Figure 5). In such cases, the presence of arcuate RNFL loss can confirm very early glaucoma – even in the absence of classic signals. Moreover, the multicolor modality is useful for improving medication compliance, as the images can make tissue loss evident to patients, motivating them to adhere to their treatment regimen. Without these pointers, the lack of subjective symptoms – particularly in early or even moderate glaucoma – results in patients failing to appreciate the need for medication.

A measure of success

In summary, measurements of the macular inner retinal layer are useful for diagnosing early glaucoma and monitoring subsequent disease progression so as to guide treatment – but are not so useful for patients who have advanced glaucoma and/or coexisting retinal disease. Modern OCT is very useful for analyzing BMO parameters, and it's possible that BMO-MRW will become the dominant disc parameter for OCT-mediated glaucoma diagnosis; however, we should remember that there can be significant age-related reduction in BMO-MRW measures in healthy subjects (2), so it will be important to adjust for age when using this measure. In my practice, I find SD-OCT very useful; multimodal imaging, eye-tracking functionality, and multicolor scanning capabilities can all assist in glaucoma diagnosis and management. I have found multicolor imaging particularly useful in borderline diagnostic cases (Figure 4). Modern systems clearly have a key place in today's glaucoma practice.

Sanjay Asrani is a glaucoma specialist at Duke Eye Center at Cary, Cary, NC, USA.

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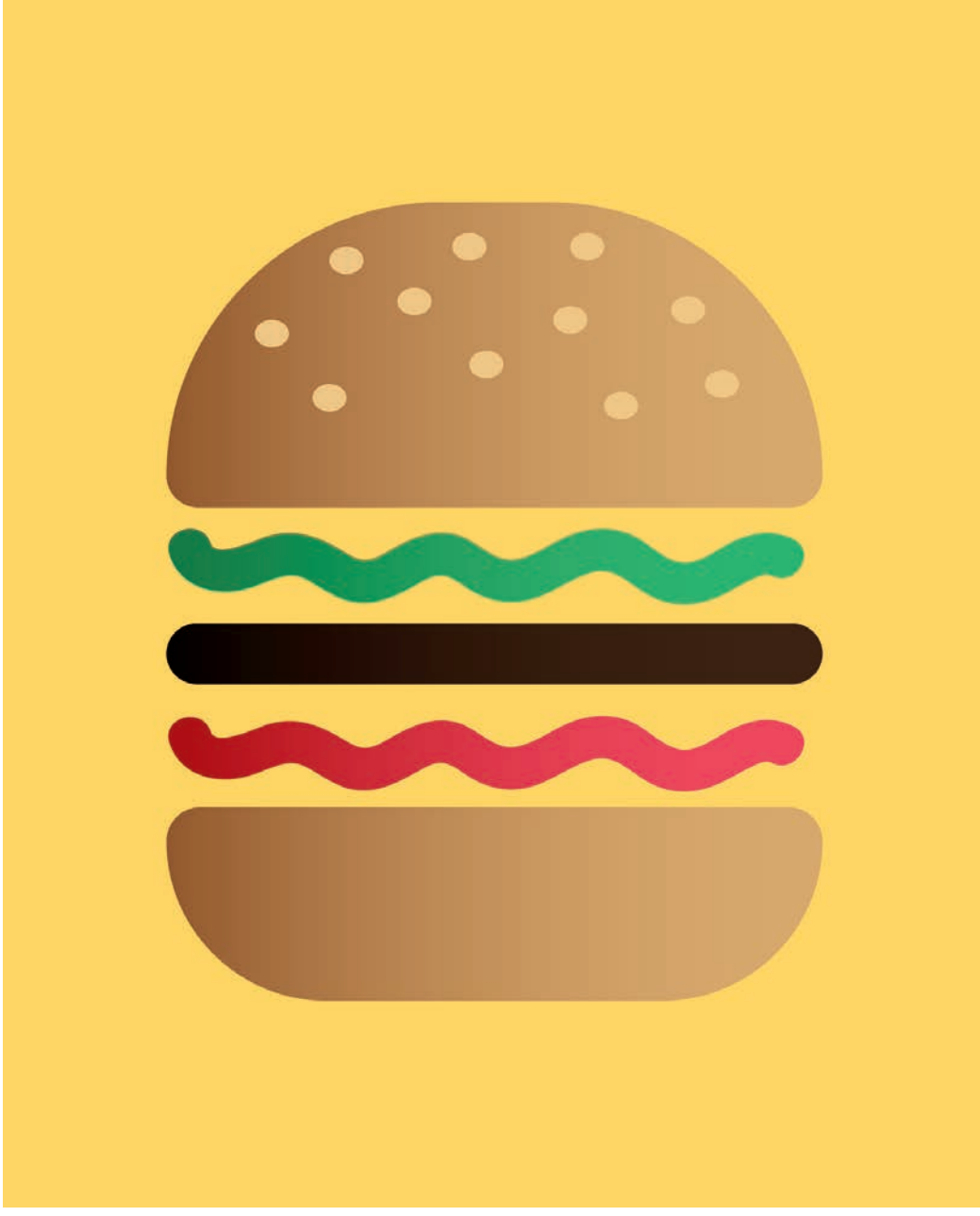
Consider What Went Right (When it Goes Wrong)

My advice for managing intraoperative LASIK flap complications

By Priyanka Sood

There is just no way around the fact that as a surgeon, you will run into complications. Managing these complications can lead to stressed surgeons, which can ultimately lead to poor outcomes and unhappy patients. Intraoperative complications can be the most challenging, as situations have to be assessed and decisions made very quickly – and seconds can really make a difference during LASIK procedures. It's why recognizing the potential issues and managing them successfully is so important. I'd like to share my 'what went right?' method, and discuss how it has helped me approach and manage intraoperative LASIK flap complications – and how it might help you too.



At a Glance

- *All LASIK surgeons encounter occasional complications during surgery*
- *LASIK is an excellent procedure and patients can still achieve great outcomes after complications*
- *I deal with intraoperative complications using a 'what went right?' method*
- *I overview my method and detail scenarios of different LASIK flap complications.*

When problems strike

Flap complications can vary depending on whether you use a microkeratome or a femtosecond laser (see Intraoperative flap complications). They can be as seemingly benign as epithelial defects or an opaque bubble layer, or more serious and 'gut-sinking' like buttonholes or vertical gas breakthrough. Whatever happens, surgeons need to keep calm and carry on, to try to achieve the best possible outcome. One thing that keeps me calm every time I walk into the laser vision correction suite is that literature is on our side. Many studies and reviews indicate that complication rates are low, and you can still have excellent outcomes if these are managed correctly (1–5).

In the suite, my 'what went right?' method helps me stay calm and logically approach issues that may arise. The method is kind of a take on the 'compliment sandwich'. At the moment of complication, take a step back to consider and remind yourself what has gone right and what might be in your favor. Then critically assess what has gone wrong, before looking to what is going right and how you can fix the problem to achieve the best outcomes for your patient. Of course, it's not always as simple as that because we all manage complications differently – that's the art of surgery. Here, I demonstrate specific

"Take a step back to consider and remind yourself what has gone right and what might be in your favor."

examples of an incomplete flap and suction loss, and discuss how my 'what went right?' method helped me during – and after – surgery.

Scenario 1 – Incomplete flap

- Performing LASIK on a patient, I suddenly got a pit in my stomach towards the end of making the flap (Figure 1a).
- Instead of immediately thinking the worst, I tried to think about what went right: the meniscus remained constant, and I could see a large round raster pattern that appeared quite circular.
- Next, I considered what went wrong? Bubbles to the infero-temporal aspect and a side cut beyond my raster pattern.
- How did I keep calm and carry on? I considered what went right, and what was in my favor: this patient was having a low myopic treatment with a small optical zone – as I tend to create larger flaps (around 9 mm) the optical zone should not be close to this irregular edge.
- Completing the case (Figure 1b); I started dissecting the flap on the side where I knew my raster pattern and side cut were normal. Coming from all angles, I was able to dissect carefully under most of the flap without issues. There was some incomplete dissection (about one clock hour) but I was able to complete the side cut with Vannas scissors. The stromal bed looked great and I was able to proceed with the case – and the patient had a great outcome.
- If I hadn't been successful at achieving the flap lift, I'd have placed it back down, waited two weeks to confirm refractive and topographic stability then performed an advanced surface ablation.

Scenario 2 – Suction loss

Suction loss is an uncommon (but not rare) complication that tends to occur more frequently in less-experienced surgeons. Known risk factors include small palprebral fissures, flat corneas, deep set eyes, patient/eye movement, large pterygia and redundant conjunctiva. Suction loss can provoke much anxiety – and it can happen very quickly. With the microkeratome flap, it is more likely that the procedure will be abandoned. But when using a femtosecond laser, it is possible to repeat suction and re-attempt the raster.

- My patient had quite deep sockets – and was also very anxious. During the raster pattern, I kept experiencing suction loss; we achieved a complete flap after the fourth suction attempt and second femtosecond pass (Figure 2).
- What went right? I was able to achieve suction and complete the flap.
- What went wrong? It was very traumatic for my patient. At the six and 12 month visits, he was still telling me he found the experience challenging.
- What could have gone better?

Intraoperative flap complications

Microkeratome
- Epithelial defects
- Incomplete flap
- Decentered flap
- Thick/thin flap
- Suction loss
- Free cap
- Buttonhole

Femtosecond laser
- Epithelial defects
- Opaque bubble layer
- Decentered flap
- Thick/thin flap
- Suction loss
- Flap tears
- Anterior chamber gas bubble
- Vertical gas breakthrough

Looking back and considering how anxious my patient was, it might have been better to abandon the procedure, and convert to advanced surface ablation. However, he was not consented to change to advanced surface ablation, and as he had received Valium it would not have been appropriate to consent the change at the time. His preference at the time was to continue with the attempts.
- Based on this experience, I now

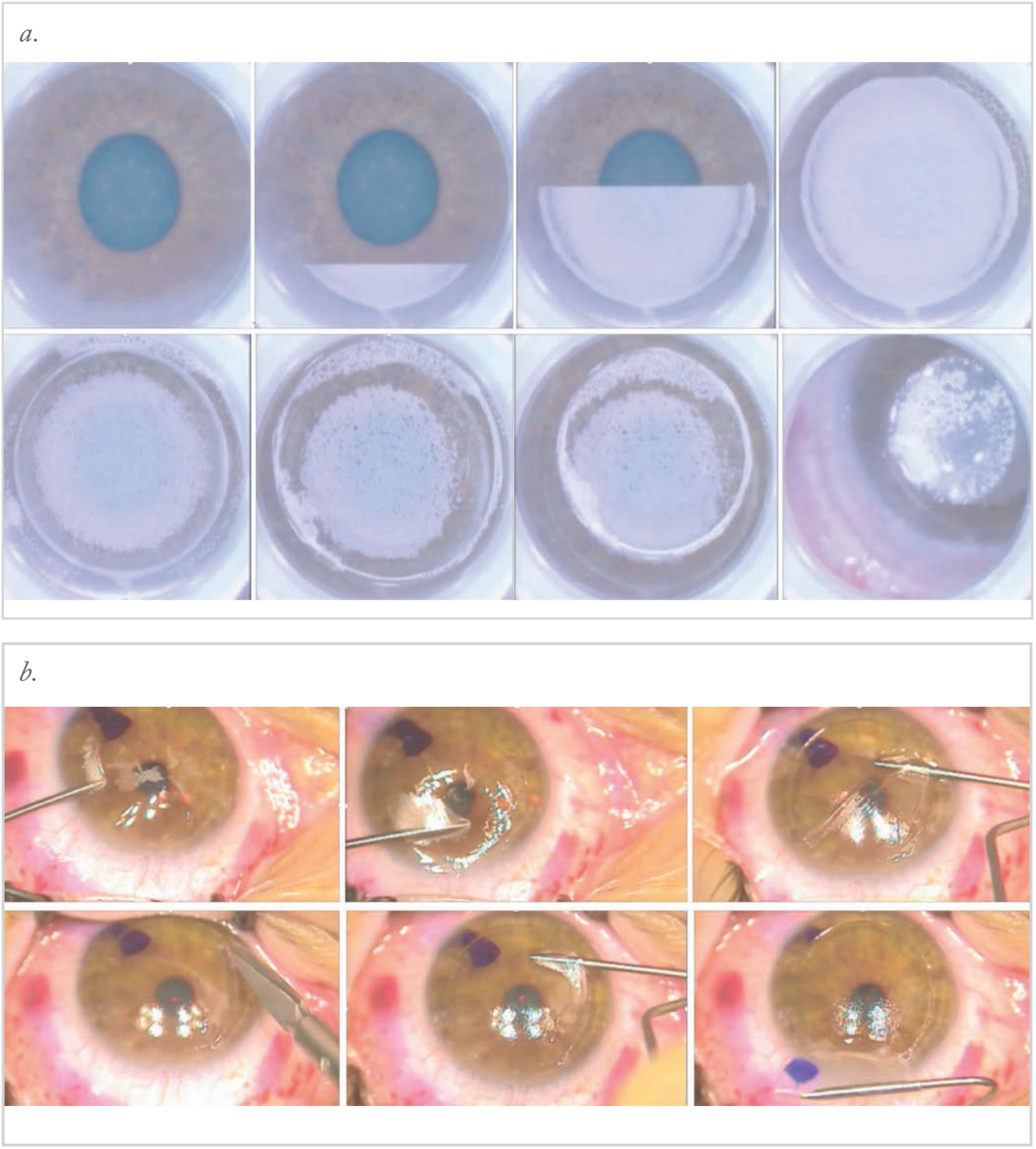


Figure 1. a. When making the raster pattern, bubbles can be seen on the superior right side and the side cut was beyond the raster pattern. b. Completing the flap through careful dissection which starts on the opposite side to the defective side cut, and using Vannas scissors to dissect the incomplete portion of the flap.

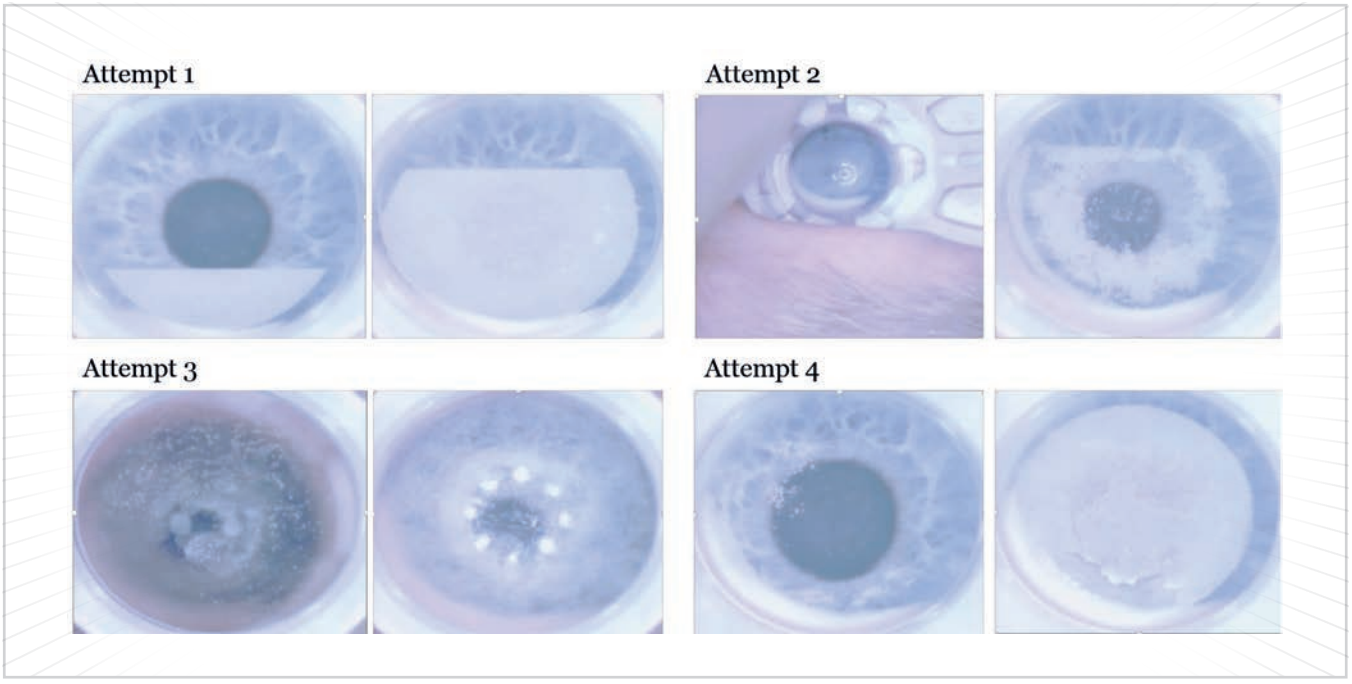
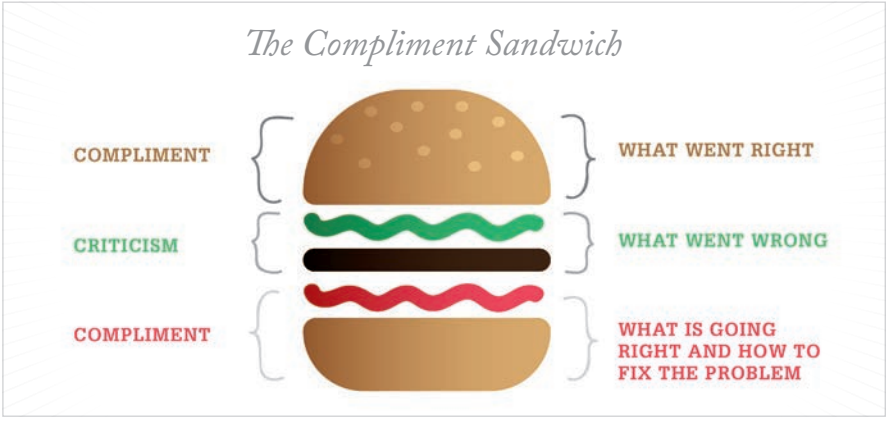


Figure 2. Successive attempts of raster pattern due to repeated suction loss.



consent my high risk patients for possible advanced surface ablation at the time of LASIK. Therefore, the patients know it may be a possibility, and if we reach the point where things become too difficult, we can convert to the procedure.

Conclusion

We know that LASIK is a safe procedure with good outcomes – even in the face of complications. In my experience, when issues arise it really is helpful to consider what has gone right before working out how to fix what has gone wrong. It is also useful to assess how to make things go 'more' right. In my case, I ended up making a positive change to my LASIK practice, which will benefit future patients. If my 'what went right?' method resonates with you, please adopt it! Otherwise, keep calm and carry on!

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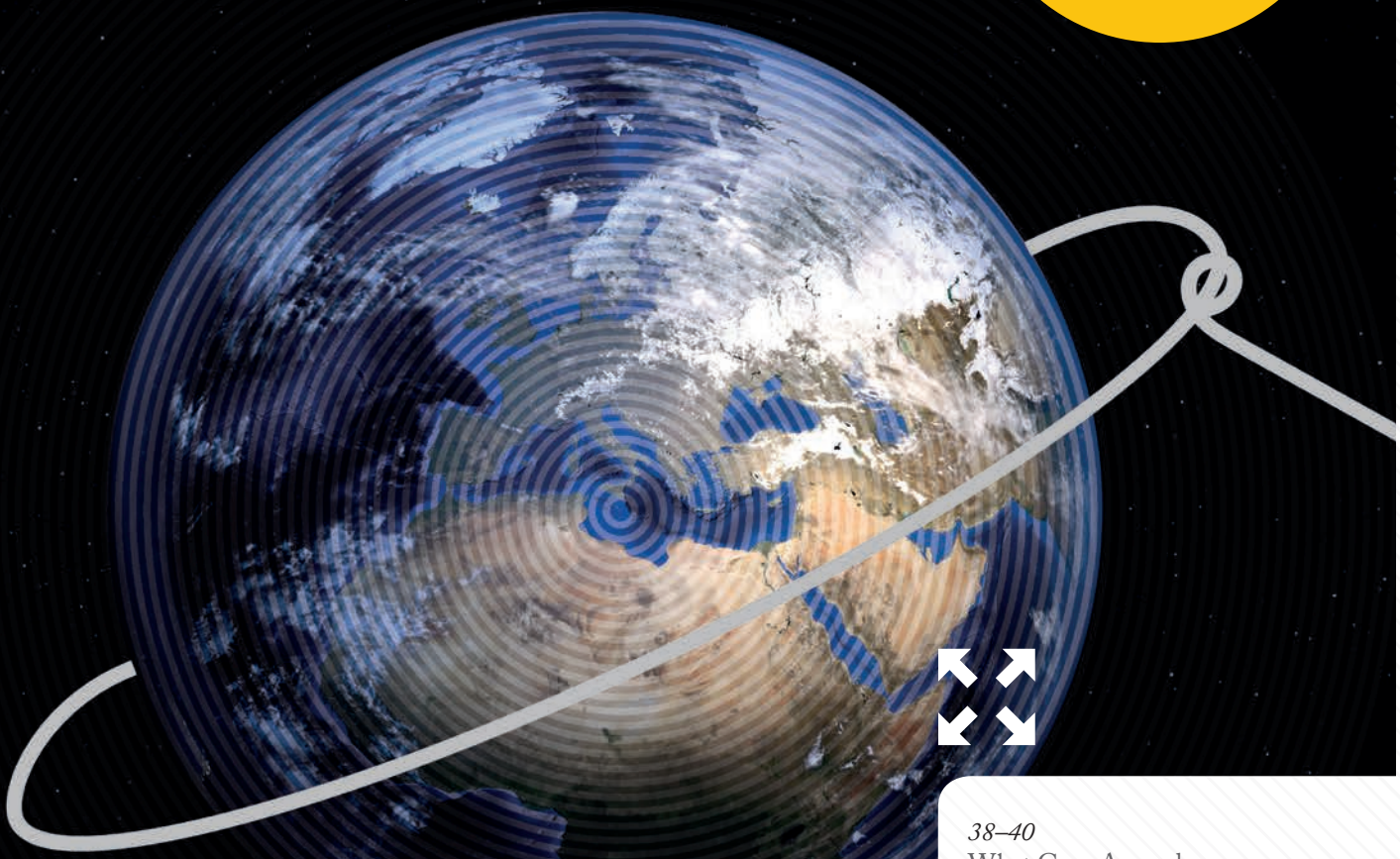

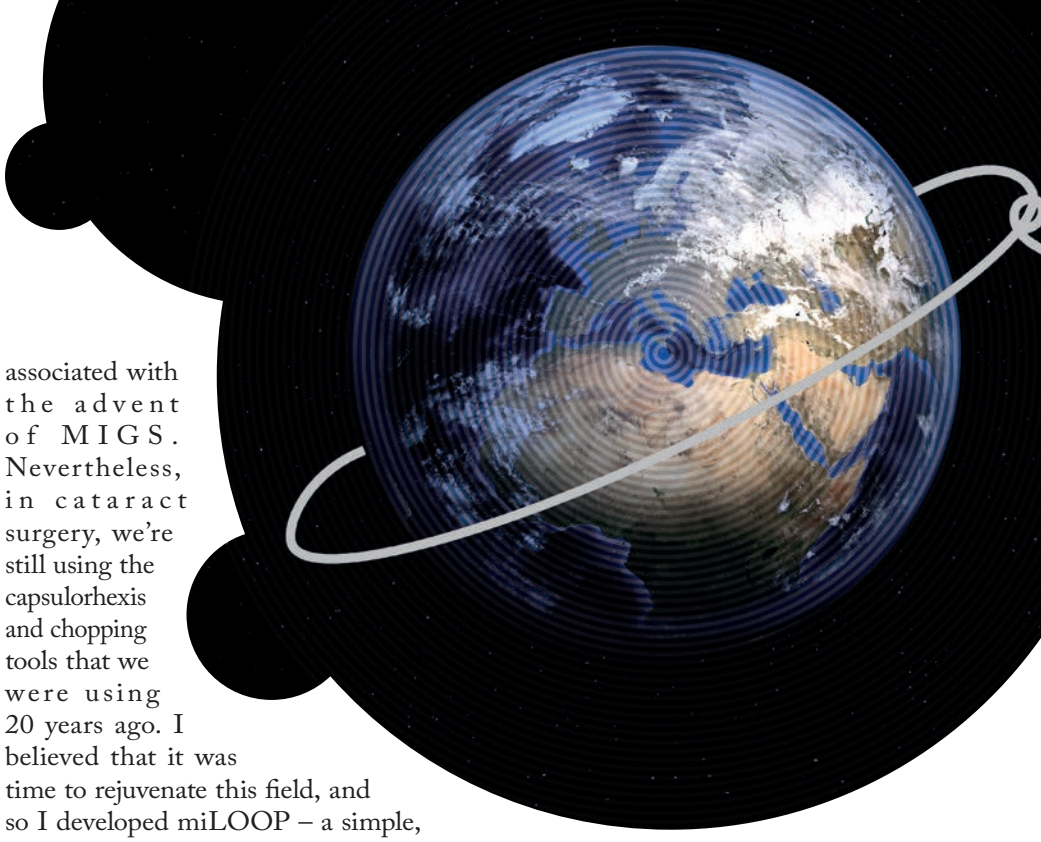

What Goes Around...

Rejuvenating cataract surgery with a simple device – miLOOP – and ensuring it reaches those who need it most

By Sean Ianchulev

Microinterventional technology in surgery isn't new; our colleagues in the cardiovascular and interventional radiology fields have been using microstents and similar devices for about 40 years. Ophthalmic surgery, however, has generally failed to benefit from these developments. But things are changing – in glaucoma, for example, we've seen dramatic advances associated with the advent of MIGS. Nevertheless, in cataract surgery, we're still using the capsulorhexis and chopping tools that we were using 20 years ago. I believed that it was time to rejuvenate this field, and so I developed miLOOP – a simple, low-cost device for microinterventional cataract surgery.

At a Glance

- *We have exploited the shape memory properties of nitinol to develop a simple and efficient cataract fragmentation device in a single-use, disposable format*
- *The miLOOP comprises a nitinol filament mounted on a pen-type actuator, and enables rapid non-thermal cutting of even the hardest cataracts without vibrational, laser or heat energy, and with no fluidics complications*
- *In consequence, miLOOP cataract surgery is faster and more efficient particularly in the context of grade 3 and 4 cataracts; furthermore, low cost and ease of use make it a viable option for both emerging and developed markets*
- *The way is now clear to address the 25 million cases of cataract-associated blindness seen each year in the developing world, and to improve the efficiency and safety of cataract surgery in the developed world.*

A not so 'cheesy' idea…

In the San Francisco Bay Area (with its proximity to Napa Valley), some of the best ideas come over "wine and cheese," as was the case with miLOOP which was conceived over a glass of wine and some hard, well-aged, aromatic cheese... How do you cut through hard cheese? You don't use a knife (nor a phaco machine) – you use a cheese wire. So, why not cut cheddar-hard cataracts the same way?! When we discussed with the engineers, we saw immediate advantages to this approach; no cumulative dissipated energy; no fluidics complications; and no phaco machine creating a centrifuge in the eye!

Over time, we slowly figured out how to make the concept a reality. The basic technology – superelastic, memory-shape nitinol – already existed, so the big challenge was applying the technology to the specific demands of the eye (using wire to cut the lens without tearing its four µm capsule is not straightforward). Indeed, the idea was so high risk that, when I formed Iantech to develop the concept, I didn't even try raising money at first and instead funded the initial development myself.

I was fortunate to partner with Luke Clauson, an engineer who has developed many interventional devices in the cardiovascular field, and, along with his team, we devised a workable device. In brief, miLOOP comprises a memory-shaped, thin micro-filament capable of loop conformations, mounted in a pen-type actuator (Figure 1). We finalized a working design in only a few months – and, amazingly, we have not needed to change it.

Essentially, the miLOOP does all the work for the surgeon by unfolding and refolding into the memory shape conformations within the capsule. All the surgeon needs to do is turn it, to allow the loop to travel around the lens, and then actuate the cut (Figure 2). Seeing the wire hug the lens surface and move around it, without damaging the capsule, is almost magical. The cutting action is very gentle and efficient (http://bit.ly/miLOOPUse); contrast that with conventional surgery, where you have a phaco needle and other invasive instruments to crack the lens, and the use of centrifugal lens fragmentation (working from the inner to the outer part), which stresses the capsule. With miLOOP, the lens is cut without

vibration or aggressive manipulation, and its action is centripetally directed (moving from the periphery to the center) – far less traumatic for the capsule, and far less risky for the zonules.

Tackling the tough mothers (aka Dura Madres)

How does the miLOOP perform in practice? From personal experience, I can tell you that it brings significant advantages for those cases I call 'dura madres' (tough mothers) – the five percent or so of cataracts that are very hard. I've seen many of these in international work, for example, in Ethiopia and Panama, and I know that surgeons are often 'scared' of them, because phaco techniques aren't adequate. But miLOOP is cataract grade-independent: it deals with dura madres as easily as with softer cataracts. I like to say it makes an average surgeon brave and a brave surgeon more efficient! Furthermore, the device is multifunctional: it not only cuts the lens, but also sweeps and polishes. Hence, even surgeons that are comfortable with hard cataracts love miLOOP, because it helps collect peripheral debris.

Importantly, the miLOOP procedure reduces the incidence of capsular tears. The real rate of capsular tears, by the way, is higher than most people admit. In our randomized control study (1), we observed a capsular tear rate of 7.5 percent in very hard cataracts, even higher with stand-alone phacoemulsification; but when we tried to publish it in the JCRS, the journal rejected the paper as they thought this rate was too high! We educated the reviewers further by bringing their attention and referencing a UK study of over 55,000 cases, which reported an overall capsular tear rate of 2 percent, increasing to 6–7 percent in harder cataracts (2). So phaco is safe enough for soft cataracts, but far riskier in hard cataracts: with miLOOP, hard cataracts become as low-risk as soft cataracts once you complete nucleus disassembly without using phaco energy. Our randomized clinical study that compared miLOOP followed by phacoemulsification with phacoemulsification alone showed that the use of miLOOP was associated with a 40 percent reduction in cumulative dissipated energy in the eye (1). I couldn't quite believe how much energy we can save by simply sectioning the nucleus with the microfilament. And, by the way, our study involved top-flight surgeons and the most advanced phaco machine on the market (we set the bar high!).

Figure 1. The pen actuator allows the nitinol loop to be inserted through a clear corneal incision and then expanded to encompass the lens. Constriction of the loop results in atraumatic, energy-free bisection of the lens, independent of cataract grade and without stressing the capsule. Loop movements have a capsular sweeping and polishing effect.

Another advantage of miLOOP is that it is very intuitive to use. Surgeon feedback indicates that the learning curve for the device is three to five cases; compare that with phacoemulsification, which can have a learning curve of 500 cases. The procedure is so elegant that it doesn't require any specialized training – it can be mastered by both manual and phaco surgeons alike. In Ethiopia, for example, where we have introduced the miLOOP, they have 40 trained nurses performing the procedure. And having operated with them, I can tell you that they are very good.

Finally, the economic arguments for miLOOP are clear. People increasingly understand that femtosecond laser-assisted surgery is associated with significant costs, which may be difficult to sustain under increasing budgetary constraints. Remember, 20 years ago a surgeon would be reimbursed maybe $2,500 per cataract procedure; today, it is $700. There is a clear need to make our procedures more efficient and less costly, which implies elimination of capital equipment costs, not assimilation of additional costs. (Given this context, it seems strange that instrumentation manufacturers are continually making bigger and more complex phaco machines). On the other hand, miLOOP is a single-use device that requires no capital investment and costs about $150.

Instant impact

The features of simplicity and low cost make miLOOP an ideal choice for resource-poor countries. The Gates Foundation-backed Global Health Investment Fund (GHIF) recognized the potential; when it invested in Iantech, it

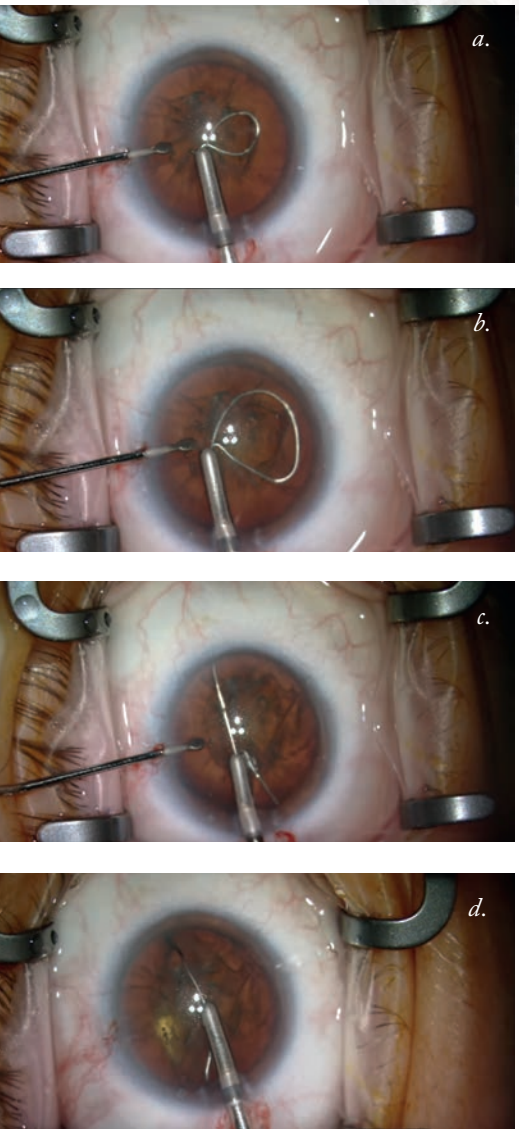

Figure 2. The miLOOP procedure. After completing a capsulotomy procedure, the miLOOP is inserted into the eye through a clear corneal incision (a), the nitinol loop expanded (b) and the fully expanded loop passed over the lens (c). The surgeon actuates the cut and the loop constricts and cuts through the lens (d). The loop is extended again, and rotated to cut the lens across a different plane. The maneuver can be repeated to cut the lens into six pieces.

was the first time a device of any form had been supported. We're very proud of that. With their help, we've set up a Global Access Program that allows free access to miLOOP in a demonstration program for at least three developing countries in 2018. So instead of the product 'trickling down' to the developed world in 20 years or so, they get access to it right now. This approach is transformational for those countries; instead of removing cataracts via a 5 mm outer incision and a 9 mm inner incision, which is pretty harsh on the eye, the patients only need to receive a 4–5 mm cut. And with next generation technology, we can be on track to go sub 3 mm. It is time to depart from the surgical technologies of the 1950s – a hook and cannula – and introduce innovation much more broadly ... and globally. The result? We can at last address the 25 million-strong backlog of cataract-related blindness in the developing world – the real benefit of working together with all vision stakeholders by enabling them through new technology which can inflect the curve in our fight against blindness.

"Phaco surgery hasn't dented global blindness in 40 years."

Consider that phaco surgery hasn't dented global blindness in 40 years, but miLOOP is making a difference right now. It's so important that previously blind people can go back to their communities, dispense with care-givers and become economically active again. You can't put a price on that. So although we won't make any money through the Global Access Program, we're helping to solve an important problem, which is immensely satisfying; the profits will come when we launch the device in the developed world.

Doing it miWAY

What about the future? At present, we are working on a second-generation device called the multi-LOOP; this folds into a triple loop to simultaneously cut in x, y and z dimensions. Rather than cutting the lens into two pieces, and then into two again – as you do with miLOOP – the multi-LOOP cuts it into three and four pieces at once. Ultimately, the idea is to 'ultra-fragment' the lens and at the same time create a port so that fragments can be removed without the need for any phacoemulsification. We expect this system to be on the market in about 12 months, and we're calling it miWAY. So while miLOOP simplifies cataract surgery and makes it safer, especially for difficult cases, next generation products will take the concept further by completely eliminating the need to introduce energy into the eye, both during and after fragmentation. The idea is to develop an energy-free, kit-based system that can be applied to any cataract, regardless of grade. In the future, I believe a small box containing a couple of disposable pen-like devices will be all that people need for cataract surgery.

Sean Ianchulev is Professor of Ophthalmology at New York Eye and Ear Infirmary of Mount Sinai, New York, USA.
Ianchulev reports that he is Founder and Chairman of the Board at Iantech Medical and Founder and CEO of Eyenovia.

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Personalizing Reality

How data-driven VR/AR is driving new insight into visual impairments

By Pete Jones

Most people have a pretty good idea of what short- or long-sightedness looks like. Many of us experience it on a daily basis, while those with perfect vision can simulate it simply by wearing glasses of the wrong prescription. There is a key gap in public understanding, however, when it comes to posterior eye diseases such as glaucoma and AMD. In those cases, light is focused correctly on the retina, but is not being encoded properly by the brain. It is hard to imagine what effect that has on our vision, and to make matters worse, the depictions you see if you search online are often wildly inaccurate. Indeed, the whole notion of drawing what a specific disease looks like is questionable, given that two patients with the same diagnosis often report very different experiences. How then can we understand what it is like to have a visual impairment? Supported by the NIHR Biomedical Research Centre at Moorfields Eye Hospital NHS Foundation Trust and UCL Institute of Ophthalmology, and by donations from Moorfields Eye Charity, we've been developing a new platform to simulate how others see using virtual and augmented reality (VR/AR).

At a Glance

- *How can eye-disease affect our sight?*
- *Current depictions of sight loss in the media can be unrealistic*
- *Using a bottom-up approach, we've developed a VR/AR platform to quantitatively simulate visual impairments, based on clinical data*
- *Here, I highlight the technology and discuss its potential applications.*

More than a blob

Many existing depictions of vision loss fundamentally involve superimposition – essentially placing a black 'blob' on top of the visual scene. The blob might be in the center of the screen in the case of AMD, around the edges if its glaucoma, or there might be lots of little black blobs in the case of diabetic retinopathy. This approach is computationally expedient, but isn't very realistic. For one thing, posterior visual impairments are not static, but move with your eyes – affecting different parts of the screen depending on where you are currently looking. Secondly, patients overwhelmingly tend to report that they don't see 'black blobs' at all. Instead they tend to report parts of the visual scene becoming blurred or jumbled, or objects simply appearing absent altogether. Indeed, you can experience this yourself: try closing one eye and observing what your blind-spot looks like. Do you see a black blob?

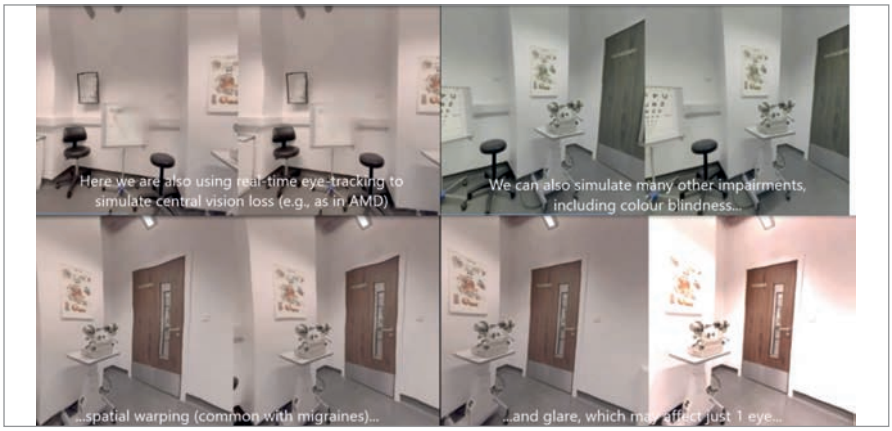
New technologies allow us to tackle both of these challenges. Firstly, we can use the eye- and head-tracking built into the latest VR headsets to make simulations gaze-contingent: localizing impairments on the user's retina, rather than on the screen. Secondly, we can use modern graphics hardware – of the sort designed primarily for computer gaming or bitcoin mining – to apply advanced image-processing techniques to an image or camera-feed in real time. For instance, with the power contained in a typical smartphone, it is relatively easy to blur, desaturate, discolor or distort an image, or to cut a hole in one area and fill it in with random shapes or textures. Our ultimate goal is to recreate the invisible nature of many impairments: removing information silently, in such a way that you don't realize anything is missing.

A bottom-up approach

Our other key design philosophy is that we want our simulations to be bottom-up: driven by data rather than disease labels. Thus, rather than starting with a diagnosis, our basic building blocks are the different properties of the visual system, such as the spatial resolution of the eye, its sensitivity to changes in luminance or color, or how straight a uniform grid of lines appears. Each of these aspects of vision can be quantified using the relevant eye-test, and all these bits of data can then be fed into the simulator. By assembling together these basic blocks, we hope to build a unique visual profile for a specific individual, irrespective of their particular diagnosis. Of course, that doesn't stop us from using big datasets to create the 'average' profile for specific diseases. For example, one of the things we did recently was compare the average vision of a newly diagnosed glaucoma patient in the UK versus one in Tanzania. The results were arresting.

It is important to stress that, despite our approach being data-driven, there is still a degree of artistic license in our simulations. For instance, there can be a lot of reasons why you may score badly on an eye-test such as a letter chart: you might be unable to read small letters because they appear blurry, or because they appear distorted, or because you

can't keep your eye sufficiently still. Ultimately, we hope to develop eye tests that can distinguish between these different causes. But for now we have to use our judgment to predict which of these causes is most likely, and it will be interesting to see whether patients agree with some of the decisions we've made.



Using the simulator...

In education

Simulations can leave an immediate and indelible impression on users. We're visual creatures; around a third of our brain is dedicated to processing visual information – it's why visual impairment can be so debilitating. So although we can read a description of something, seeing it often has much greater impact. Our VR/AR headset delivers a huge amount of information in just a few seconds, and very quickly gives people a sense of how a condition might affect everyday life in a way that is not always possible from reading a textbook or viewing a static image. Even having created them, some simulations have surprised even me; seeing the VR experience of nystagmus for example was really shocking. While at public events, people are often surprised to see how little some conditions such as color blindness actually affect one's ability to perform day-to-day tasks. Consequently, we're looking into the impact of the simulator as a teaching and empathy aid, and we have an ongoing trial with City University School of Optometry (London, UK) to assess whether the simulator improves understanding and empathy amongst new optometry students compared with reading the textbook alone. We want to see in particular whether the simulator makes new students better at predicting what challenges a patient will face.

We are also exploring the use of the simulator as an educational tool for the public. Generally, people aren't good at recognizing the signs of visual problems – for instance, diagnosis rates for glaucoma are alarmingly poor (some people think as low as 50 percent). Accurate simulators could raise awareness of how vision may be affected in the initial stages of disease, helping patients recognize potential issues earlier, and when they can be more effectively treated. Further, showing how a patient's visual impairment is likely to progress might help encourage patients to comply with their treatment regimen. We have been particularly inspired in this respect by Peek Vision, who do a lot of work in developing countries, and who found that providing parents with a printed depiction of their child's vision made them more likely to attend future appointments.

In research

Sight loss simulators can also be a powerful tool for research. Being able to explicitly control and manipulate exactly what the user sees gives us a unique opportunity to reexamine long-standing scientific questions from a fresh perspective.

For example, a lot of clinicians have noticed that the eye tests we use most often (letter charts, perimetry, and so forth), tend to be relatively poor at predicting a patient's quality of life. So you can have two people with the same test score, but each reporting very different levels of impairment. Is this because the tests are not capturing all the key information? Or are some people better at coping with sight loss? Simulators allow us to systematically tease apart these two hypotheses. For instance, in one study we are currently running, we are using AR to give different people the exact same impairment. We are then asking them to perform a range of tasks, including various different eye-tests, as well as the sorts of everyday tasks that patients often find challenging, such as finding their mobile phone or making a cup of tea. We can then

observe directly whether some eye-tests are better than traditional measures at predicting performance on everyday tasks. Furthermore, by analyzing the eye, head- and body-tracking data from the headset, we can examine why it is that some people are better able to cope with their impairment. Maybe in the future we might even be able to teach everybody the coping strategies that our best-performing participants identify.

As well as giving different people the same impairment, we can also do the opposite experiment – giving the exact same person a range of different impairments. In this way, we can study how different patterns of sight loss affect everyday life, while controlling for all other factors, such as age or physical fitness. This will ultimately allow us to develop better ways of quantifying an individual's expected level of impairment, which is vital when assessing how effective a new therapy is, or when deciding how to prioritize patients. In the long term, we hope that such experiments with 'simulated patients' may help us devise better ways of predicting an individual's needs, allowing us to preempt difficulties before they arise.

In accessibility

As society ages and rates of visual impairment increase, there is an ever greater need to develop environments and products that are accessible to everyone. I envisage that simulators such as ours will become a vital tool for engineers and architects: allowing them to see for themselves whether or not a space is usable, and how it can be made more welcoming for people with sight loss. Is this train station easy to navigate? Is this website readable for people with low vision? By using AR or VR, you can simply look and see. Perhaps the most exciting aspect of this approach – and the reason why I think it will really take-off – is that the problems identified are often easily addressed. For example, it might just require using a thicker marker pen to write on a whiteboard, or changing the color of the lighting around a particular staircase. These are small changes, but they can make a big difference to people's lives, and are solutions that often aren't apparent until you see the world through someone else's eyes.

Looking ahead

It is clear that VR and AR will have a huge impact on eyecare in the future. If eye tests aren't being performed at home using VR/AR headsets in the next 5–10 years, I will be very surprised – and disappointed really, as we already have a lot of the necessary technology. As for our simulator, we don't yet know what the most useful application is going to be, and we're still at the stage of exploring to see what works and what doesn't.

To a large extent, the future of sight-loss simulations will also depend on how the technology evolves. In terms of software, the signs are already extremely encouraging; a lot of the historical hurdles are tumbling. For example, in the past it was a nightmare trying to adapt code to support different devices. But these days it usually only takes a few clicks to transfer our simulator from one type of VR/AR headset to another, or from an android smartphone to an iPhone; I even got it running on the display of my fridge-freezer display last week, although kneeling down in the kitchen doesn't make for an ideal viewing experience. In terms of hardware, there's still some room for improvement though, and I expect we'll see some big leaps forward in next 3 years. For example, at the moment, the headsets are fairly bulky; in the future I hope to see the same technology built into an ordinary pair of glasses, which will make applications such as our simulator much more accessible. Fortunately, a lot of the big gaming and home-entertainment companies are really pushing the hardware forwards, and we can piggyback on any new development as they become available. And ultimately it is this that makes this such an exciting area to be working in; simulation spectacles have been around a long time – it's just that, in the past, they've involved glasses with black spots glued onto them... Now, because we have all of this amazing technology, we are only really limited by our imagination, and who knows where the future will take us – or what we will discover along the way?

The VR/AR simulator

- The user wears a VR/AR headset to look at either pre-recorded videos, VR environments, or the real-world via front-facing cameras ('Augmented Reality'). The images are then filtered in real-time through a series of digital processing effects designed to mimic various aspects of visual impairments. The digital filters are based on clinical test data, such as perimetry or letter-acuity.
- Images can be delivered independently to each eye, and eye tracking allows impairments to be displayed relative to the user's gaze (i.e., localized on the retina).
- A video of the simulator in action can be viewed here: *http://www.ucl.ac.uk/~smgxprj/videos/vr_info.mp4*

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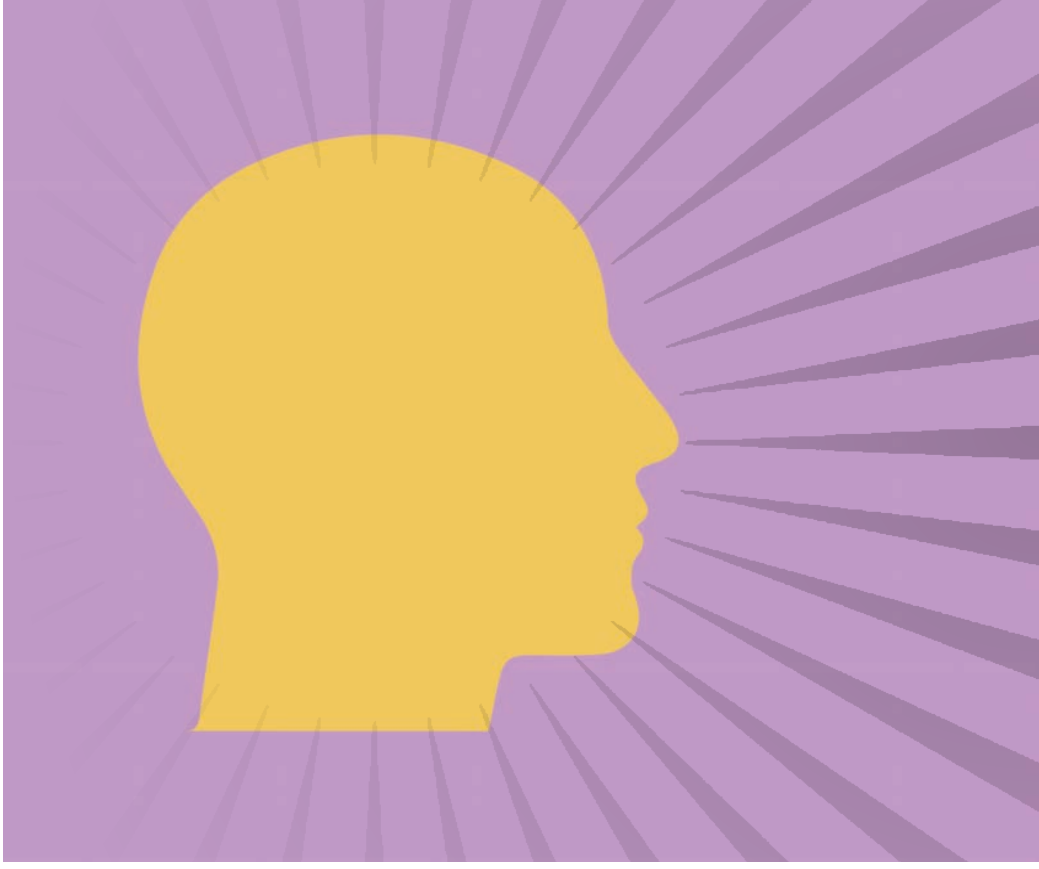

The Peer-to-Peer Network

Finding out why – and how – ophthalmologists on both sides of the podium value peer-to-peer education

By Jessica Griffith

Anyone who has spent time in the crowded lecture halls of a national meeting will have seen physicians seeking out opportunities for peer-to-peer education. But the lecture hall isn't the only venue; ophthalmologists also share knowledge and learn through one-on-one discussions, publications, webinars and videos.

In March 2018, we conducted an email survey with 25 ophthalmologists working in multiple subspecialties in North America and Europe, as well as industry professionals, to gain perspectives on peer-to-peer education from the ophthalmology community. All participants were asked about how they view such education, where and how they prefer to give and receive it, and how taking on the role of educator has influenced their careers. From this diverse group, we identified some clear trends and a few surprises.

At a Glance

- *As eyecare constantly advances, the knowledge and skills of ophthalmologists must keep pace*
- *Peer-to-peer education is one key method of keeping up-to-date*
- *Several leading ophthalmologists who frequently teach and learn from their peers were surveyed*
- *We share their thoughts on the value of peer-to-peer education, and how best to approach it.*

Assessing value

When physicians were asked about the perceived value of peer-to-peer education, several recipients offered comments on how they both learn and educate others in this mode. Joshua Mali (The Eye Associates, Sarasota, FL, USA) described peer-to-peer education as a "critical component of life-long learning," adding, "it helps to establish the standard of care, advance our field, and provide new ideas and innovations to the ophthalmology community."

Peer-to-peer education takes many forms, as described by Cynthia Matossian (Matossian Eye Associates, Mercer County, NJ, and Bucks County, PA, USA): "Sharing knowledge with peers is how we stay abreast of current developments in ophthalmology, whether through sponsored webinars, one-on-one calls with eyecare providers, lectures, presentations, or panel discussions at local or international meetings."

But what methods of education are preferred? Interaction in small groups or one-on-one are highly valued, with respondents noting that intimate environments encourage a greater depth of learning and bonding among colleagues.

Several physicians acknowledged the 'immediacy' of peer-to-peer education, which, according to Sumit Garg (Gavin Herbert Eye Institute, University of California, Irvine, CA, USA), often lets physicians learn about "technologies, techniques, and medications prior to randomized clinical trials or peer-reviewed published papers."

New horizons

To delve into the written word in peer-to-peer education, we asked, "What was the last article you read that made you think, 'I need to learn how to do this'?"

Responses pertaining to cataract surgery included the Yamane technique for scleral haptic fixation, capsular ring techniques, and the RxSight light-adjustable IOL (RxSight, Inc). Refractive topics of interest included ReLex SMILE (Zeiss), wavefront-guided LASIK combined with SMILE, topo-guided LASIK in irregular corneas, as well as new corneal inlays. Other topics included ab-interno canaloplasty (ABiC; Ellex) for glaucoma, corneal transplant with "grip and rip" anterior lamellar keratoplasty (ALK) and Luxturna gene therapy (voretigene neparvovec-rzyl, Spark Therapeutics) for inherited retinal disease.

Ophthalmologists reported looking to a variety of sources for more information on these advances, with the majority learning more about the treatment or technique at major meetings (Figure 1).

A plethora of publications exist in the ophthalmology field – but how frequently are they read? On average, the physicians reported referencing ophthalmology trade publications online or in print 9.8 times per month, with 31 percent reading 20 or more times. Several respondents said they get information through meetings or other means and only access articles when they are putting together presentations, whereas others said they read the ophthalmology literature "constantly."

Next, we asked if subscriptions and paywalls present any frustration? Most physicians reported that academic journal paywalls hadn't blocked them from reading an article (62 percent), and many said they subscribe to the journals or work at institutions that subscribe. Others reported dissatisfaction with paying or using the varied methods to access the journals. Although Amir Hamid (Optegra Eye Health Care, London, UK) has not allowed paywalls to stand in his way, he noted, "[they can] represent a significant barrier to dissemination of knowledge to a wider audience." Perhaps this is why 92 percent of respondents find it important that their own educational content is published in a free-to-read publication.

"92 percent of respondents find it important that their own educational content is published in a free-to-read publication."

Industry events versus CME

Our survey respondents have given many CME and podium lectures, and participated in numerous industry panels. But do these different environments – academic, CME and industry sponsored – affect the content or quality of the material shared? Yes, according to 64 percent; respondents noted that industry-sponsored and academic environments are different – but both have value. Identified advantages of industry events were learning about new drugs or technologies and their 'on-label' uses; CME was identified as offering more 'freedom' to share on- and off-label uses, answer questions and have a more candid, unconstrained discussion. One doctor noted that non-industry, non-CME presentations offer the most flexibility, but all respondents who present at industry events said that they offer their honest experiences, unaffected by the sponsor's influence.

"Education has changed greatly over the past several years," observed Eric Donnenfeld (Ophthalmic Consultants of Long Island and Connecticut, NY and CT, USA). "Due to strict guidelines, most industry-sponsored talks have become very cut-and-dried, with no room for going off the legal department-approved script, much less off-label." Matossian agreed with Donnenfeld, but also made the point that "industry-sponsored roundtable talks play a key role in disseminating information when a new drug or device is launched."

Social media and digital access

What about accessing peer-to-peer education outside of major meetings? Online presentations, such as convenient and cost-effective live webinars and videos, were well-appreciated by respondents. Is social media genuinely useful for peer-to-peer education? Yes, according to over half of the doctors (Figure 2). Positive comments related mostly to streaming or sharing videos via social media channels. "Social media gives you access to a wide audience with a few taps on the keyboard," said Hamid. "While on an educational tour of India, we used this form of communication to access a large number

Figure 1. How ophthalmologists learn new techniques and advances. Whilst the majority report learning from major meetings, conversations with peers and trade publications, a small percentage note the value of YouTube for education.

of ophthalmologists without having to travel the length and breadth of a huge country. They could participate in Q&A sessions in the comfort of their own local clinics, hospitals and universities."

Those doctors less certain about the potential of social media (with "no" or "not sure" responses) noted that they are open to the possibility in the future.

Whilst one respondent reported using social media to share educational content with colleagues, another thought that social media channels lack the necessary depth for education but do help "provide insight or intrigue." One respondent reported that social media channels are "not at all" useful for education because content tends to be promotional.

PR machine

Physicians who educate their peers at conferences and other events invariably raise their professional profiles and their

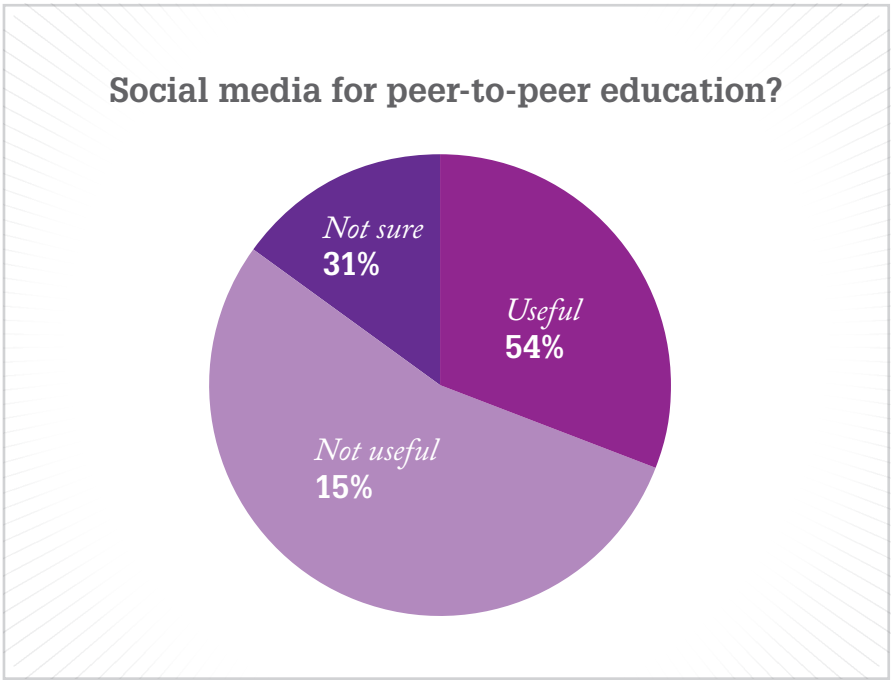

Figure 2. Ophthalmologists' opinion on whether social media is a good platform for peer-to-peer education.

practices' visibility. When we asked if the doctors use educational opportunities to market themselves and their practices, a large majority of respondents (77 percent) said they see the positive effects of education on their reputations, but many said they do not educate with marketing in mind.

"I do not see it as marketing," Hamid stated. "But educational opportunities do increase your profile and lend credibility to what you say in the context of patient consultations in your practice."

Lisa Nijm (Warrenville Eyecare and LASIK, Warrenville, IL, USA) agreed: "I don't use educational opportunities with the goal of marketing my practice in mind, but I certainly believe there is an additional benefit: other practices have learned of the different specialty procedures I perform and complex conditions I treat, and that has resulted in additional referrals."

As Donnenfeld pointed out, "Doctors like to refer to thought leaders." Mali said that educating his peers has "helped to build my strong reputation on the national and international stage."

For those physicians who want to expand their visibility through peer-to-peer education, Nathan Radcliffe (New York Eye and Ear Infirmary, New York City, NY, USA) offered some advice: "I think the key is to 'pound the pavement' and try to achieve a diversity of visibility, including trade and peer-reviewed publications, major meetings, email marketing, online videos and paid promotional events. The payoff is gradual and quite modest." Some direct marketing efforts cited by the respondents included providing education for the public and for referring ODs, as well as promoting or highlighting educational events on social media.

Take-home messages

Clearly, peer-to-peer education is highly valued by ophthalmologists, with colleague interaction and small group discussions being identified as useful ways of gaining the in-depth knowledge needed to stay current. One key take-home we identified was the enthusiasm for video content – whether through webinars or social media platforms – and it would be interesting to see how video content might shape peer-to-peer education in the future. Some publications have already adopted video outlets, but given ophthalmologists' preference for meetings, how would live streams or on-demand videos be used to achieve their educational needs?

As well as the clear benefits in furthering knowledge, several of our respondents also reported that teaching peers had improved their professional profiles. Whilst not a primary aim of peer-to-peer education, getting involved helps new physicians build their own reputations and practices.

Nijm offers the ultimate summary of peer-to-peer education – and its impact on the ultimate beneficiaries: "It's a great avenue to procure knowledge surrounding real-world clinical scenarios that ophthalmologists face every day. It gives me the opportunity to share learnings with my colleagues to help us all attain better outcomes for our patients, especially in challenging clinical scenarios."

Jessica Griffith is Director of Professional Practice at Pascale, an international healthcare communications company (www.pascalecommunications.com).

Ask the Industry Experts

As a follow-up to our physician survey, we asked decision-makers in industry how they develop peer-to-peer education on their emerging ophthalmic technologies. Here are a few key insights.

Preferred method of educating physicians about company products?

- "Advertisements help maintain a product's visibility, but for greater impact and to provide the potential user with more information, I focus on trade articles or advertorials."
- "I like to create educational resources (print, podium, digital) focused directly at the end user/buyer."
- "Trade articles, CME meetings, industry meetings and webinars are all effective educational tools. I don't see an advertisement as an educational tool unless it's a sponsored article or supplement."

The role of social media in peer-to-peer education?

- "It's difficult to educate in less than 250 characters. Social media is more useful for building awareness and keeping our products top of mind. It can be a useful way to point to an educational source – for example, we use social media and eblasts to point to webinars."
- "I see the utility of social media in expanding one's presence, however, I'm more old school and like to stick with getting KOLs focused on podium presentations or product-driven articles."
- "I use digital media or create practice-building materials as additional tools outside of the product to reach the end user or supporting staff."

The Selfless Surgeon

Sitting Down With... Alan Crandall, Director of Glaucoma and Cataract, Senior Vice Chairman of Ophthalmology & Visual Sciences, University of Utah School of Medicine, USA, and Senior Medical Director, Moran Global Outreach Division.

Why ophthalmology?

Originally, I wanted to do a chemistry PhD – I only switched to medicine during my third year. At first, I was aiming for a residency in radiation oncology, but then realized I wasn't psychologically equipped for a specialty where the doctor can't win! And that's why I went into ophthalmology – you can actually cure people.

And why cataract and glaucoma?

I started out as a glaucoma surgeon but adopted phaco very early (before it became popular), so I never really considered the two as separate disciplines. I still think the glaucoma surgeon should be a great cataract surgeon as well. All the cases that require real skill to treat – such as pseudoexfoliation, traumatic glaucoma, pediatric patients and small pupils – are found in glaucoma patients.

Looking back over your career, what gives you the most pride?

Knowing that I was one of a small number of surgeons willing to teach others is very satisfying. I'm also pleased that I supported an environment that enabled formation of the ASCRS. Back when Charles Kelman was being treated as a pariah and the Academy did not accept phacoemulsification, we had to develop a space for people to discuss phaco, because there was nowhere else to go. The meetings were run by David Kartcher at the Beverly Hills Hilton and, from that, he eventually got asked to set up a new organization, whichis the ASCRS. Finally, my international ASC work has been immensely rewarding: as Senior Medical Director of Moran's Global Outreach Division, I've worked in developing countries including South Sudan, Tanzania, Guatemala, Nepal, Haiti and Micronesia.

What advice would you offer to a new surgeon?

Don't be in too much of a hurry; maintain soft fingers in every single maneuver; and remember that no part of the phaco procedure is inconsequential. Even the primary incision step is critical; too flat, and your second instrument will cause corneal stria, too steep and fluid will pour out of the eye; if the wound is incorrectly done you may get kimosis, and if it's too tight you may get a corneal burn…

Also, if you get a problem, stop and analyze the situation. Above all, don't immediately come out of the eye; first, stop the ingress of fluid; next, inject viscoelastic, and then look and think. Break down each part of the surgery to identify the cause of the problem.

Finally, be aware that the only way to have no complications is to do no surgery! Regardless of how good you are, one day something will go wrong. Your complication rate may go down over time, but it will never reach zero. You'll get better with time, but to speed up the development of your skills, I recommend that you video and revisit every case you do – it's amazing what you find out about your own technique!

What drives your work in developing countries?

I have always been passionate about helping others. And when you fix somebody's eyes in the developing world, you free up two people: the blind person and their caregiver. It makes a massive difference in those countries, and I think it will benefit the developed world too, eventually. It's like the concept of a butterfly's wings starting a wind that goes far; I believe that kindness to individuals ultimately helps society as a whole.

Of course, working in those environments isn't always easy. Sometimes, we'd have to carry instruments to avoid them being impounded and incurring fees at customs; I've had to wear the same clothes for two weeks because all my hand luggage space was taken up by a donated phaco unit! And in South Sudan, we had to negotiate with three rival tribes who all spoke different languages, so we needed three interpreters. We eventually got permission from them to treat patients, but, after two years, North Sudan closed the borders, and we had to cease operations and get out. I've also spent time in Afghanistan, Pakistan, and Iran – it's interesting how, despite sanctions, they had all the best American equipment! One of the beautiful aspects of ophthalmology is that we can share cures for blindness, and I hope that contributes to the spread of peace.

What can we learn from developing countries?

I think we can learn a lot, partly because our future needs will be met by a combination of high-tech and low-tech. Look at miLOOP: it's a modern, much nicer version of an old technique – the wire snare. Similarly, India and China are now developing low-cost phaco units, and I think we may also see those machines being adopted in the developed world. We can also learn from their attitude to waste and recycling. Over there, there's no such thing as a single-use instrument, but their complication rate is no higher than ours; do we really need to focus on disposables so much? Finally, we can pick up very useful skills by working in developing countries; for example, you see much harder cataracts there than in the West. And we shouldn't forget that people in need exist in the developed world too: that's why, for example, we run a free clinic for the homeless in Salt Lake City. The skills and low cost innovations we see in the developing world could well benefit those from any resource-poor context.

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