SMILE: Exceeds LASIK, two years of clinical data

Kimiya Shimizu, MD

Kimiya Shimizu, MD, Tokyo, started performing SMILE at his clinic in 1997 but stopped in 2008. His reason was most complications from LASIK continued not only immediately after surgery but for a significantly long period of time after. Take, for instance, epithelial ingrowth. Cases can return 14 years after flap-making LASIK with the complication. It is not a very common complication, but it is not so rare. The most common complication following flap-making LASIK is dry eye. At five years after LASIK, tear breakup time shortened to an average of 4.2 seconds from an average of 9.1 seconds in 55 patients. In addition, while 18% of LASIK patients were using some kind of medicine for dry eye preop, the percentage rose to 78% postop. Other complications can manifest later. Among them are filamentous keratitis, which can appear two years postop, and superficial punctate keratitis (SPK), which can manifest as far out as 12 years after LASIK. 

Flapless refractive surgery – SMILE 

Most complications following LASIK are caused by the flap. The next step is therefore flapless surgery through a form of refractive lenticule extraction: SMILE. 

Flapless surgery is performed using the VisuMax femtosecond system (Carl Zeiss Meditec Inc., Jena, Germany). Femtosecond lasers do not ablate; rather, they remove tissue by photodisruption. For laser vision correction based on ablation; rather, they remove tissue by photodisruption. It creates a precisely shaped femtosecond system on the market that is able to perform ReLEx. It creates a precisely shaped lenticule that consists of two cuts referring to each other with high precision, and the laser settings can be adjusted according to the optimal combination between spot size and energy.

**SMILE vs. FLEX**

Dr. Shimizu compared two iterations of ReLEx—femtosecond lenticule extraction (FLEX) and small incision lenticule extraction (SMILE)—looking at 60 eyes of 30 patients. In both procedures, a lenticule of intrastromal corneal tissue is removed to alter the shape and hence refractive characteristics of the cornea; the difference is that FLEX still requires a flap for removal of the lenticule, while SMILE constitutes a further development of the procedure and allows the extraction of the lenticule through a small incision that is also created using the femtosecond laser. 

Refractive outcomes were comparable between the two procedures in terms of manifest spherical equivalent (SMILE –4.09±1.60 D vs. FLEX –3.99±1.66 D, p=0.61), manifest cylinder (SMILE -0.57±0.72 D vs. FLEX -0.69±0.75 D, p=0.19), logMAR uncorrected visual acuity (UCVA; SMILE 1.12±0.22 vs. FLEX 1.07±0.27, p=0.06), and logMAR best corrected visual acuity (BCVA; SMILE –0.23±0.06 vs. FLEX –0.23±0.06, p=0.67).

The visual outcomes remained comparable one year postop. There was no difference in terms of visual acuity, efficacy index (SMILE 0.80 vs. FLEX 0.80), safety index (SMILE 0.90 vs. FLEX 0.90), stability (one month – one year: SMILE –0.12 D vs. FLEX –0.09 D), and predictability (SMILE 100% vs. FLEX 100%).

One difference that emerged in the study was in terms of indices of comfort. On the visual analog scale (VAS), SMILE scored an average of 34.8, 31.7, and 38.6, while FLEX scored an average of 91.1, 86.7, and 87.1 (p<0.001) for pain, tearing, and discomfort, respectively. The Schirmer test also decreased more in the with-flap FLEXsurgery than with SMILE, but the difference was small and mostly disappeared by six months (SMILE 12.4 vs. FLEX 12.1).

A bigger difference was seen in terms of tear breakup time (TBU). TBU remained stable after SMILE surgery, but decreased over time up to one year postop with FLEX surgery (p<0.001 at each time point).

The differences of pain and TBU (and subsequently dry eye) may have to do with the effect each procedure has on the subbasal nerve plexus of the cornea. Flap making damages the nerve plexus as shown by examination of the cornea under confocal microscopy after the two procedures at different time points: preop and postop one month, three months, and one year. Subbasal nerve density was consistently higher postop with SMILE. Nerve density was reduced to about 50% with SMILE, and went down to about 10% with FLEX (p<0.05).

SMILE is therefore the less invasive procedure. One year after the surgery, fluorescein staining revealed a better ocular surface with SMILE. 

ReLEx: Two-year data

At the Kitasato University School of Medicine, Dr. Shimizu has performed ReLEx on 202 eyes (101 FLEX, 101 SMILE). ReLEx scored consistently high at different time points in terms of safety index (from 0.79 at one day to a peak of 0.98 at one year, leveling off at 0.93 at two years postop) and efficacy index (0.65 at one day, rising to and leveling off at 0.86 by six months postop). The refraction also remained stable up to two years, and predictability of ±0.5 D was 100% by two years—better results than with LASIK. There were some complications. Intraoperatively, suction loss was observed in four cases (2%). The most common postoperative complication observed was transient interface haze (15 cases, 7.4%); however, haze disappeared after administration of topical steroids. Diffuse lamellar keratitis was seen in two cases (1%), while one patient requested a small enhancement (0.5%). There were no cases of infection or of epithelial ingrowth.

ReLEx vs. LASIK

Dr. Shimizu compared ReLEx with LASIK in terms of higher order aberrations (HOAs), ocular light scatter, and surgery time. 

In a study comparing ReLEx, specifically FLEX, with wavefront-guided LASIK, Dr. Shimizu and his colleagues found that the two procedures were comparable in terms of third-order and total HOAs, but were significantly different (p<0.001) in terms of fourth-order aberrations (ReLEx 0.07 microns change in HOAs, LASIK 0.29 microns change in HOAs). With LASIK, the fourth-order aberrations increased according to the amount of spherical equivalent correction (p<0.003); no significant correlation was found between HOAs and spherical equivalent correction in ReLEx (p=0.05). The reason for this has not yet been determined. Because some transient haze forms immediately after surgery, ocular scatter increases with ReLEx in the early postop period, but gradually recovers with time.

Finally, in terms of surgery time in Dr. Shimizu’s hands, ReLEx, specifically SMILE, took about half the time to perform wavefront-guided LASIK—SMILE took 4:09 minutes, wavefront-guided LASIK took 10:02 minutes.

ReLEx thus produces good results with fewer complications compared with wavefront-guided LASIK. In the past, Dr. Shimizu has performed PRK, mini-PRK, LASIK, and, most recently, wavefront-guided LASIK. He began performing ReLEx, specifically SMILE, in 2010, and today he considers it the best option for refractive surgery.

Reference


Dr. Shimizu is professor and chairman of the Department of Ophthalmology, Kitasato University School of Medicine, Tokyo. He can be contacted at kimiya@med.kitasato-u.ac.jp.
SMILE: An intrastromal form of keratomileusis

Innovation: Seeing beyond

History of intrastromal refractive surgery
Ever since femtosecond lasers were first introduced into refractive surgery, the ultimate goal has been to create an intrastromal lenticule that can then be removed in one piece manually, thereby circumventing the need for incremental photodisruption by an excimer laser. Early studies were made using picosecond lasers (1996) and femtosecond lasers (1998-2003), however, these did not culminate in actual clinical trials.

Production of the VisuMax femtosecond system (Carl Zeiss Meditec Inc., Jena, Germany) in 2006, the intrastromal lenticule method was reintroduced in a procedure called femtosecond lenticule extraction (FLE), which involved lifting a LASIK flap to allow the removal of the lenticule. Given the success of FLE, the procedure evolved into its current flapless form known as SMILE (small incision lenticule extraction). The SMILE procedure involves creating one or two small incisions through which the lenticule interfaces can be separated allowing the lenticule to be removed, thus eliminating the need to create a flap. The results of the first prospective trials of SMILE have been reported.

VisuMax design elements enabling refractive lenticule surgery
The VisuMax femtosecond laser is currently the only femtosecond laser being used for intrastromal lenticular surgery. In order for accurate 3D intrastromal cutting, a number of technological hurdles have to be overcome; not only does the femtosecond pulse placement 3D accuracy need to be very high and pulse energy very low, but there has to be minimal tissue distortion of the cornea during optically coupling to the femtosecond laser source. There are six distinct design elements of the VisuMax that represent how the device was conceived from the ground up as a high precision intracorneal lenticular cutting tool. First, the coupling contact glass is curved in order to minimize corneal distortion. Tissue distortion is further minimized as coupling suction is applied to the peripheral cornea (not the conjunctiva/sclera) allowing for immobilization of the cornea using a very low suction force. A third mechanism for minimizing tissue distortion is that the optical beam path is suspended on a fulcrum with force-feedback servo control of the height of the patient bed and headrest, thus maintaining a consistent force onto the cornea. The beam uses a very high numerical aperture, designed to deliver a very tight concentration of femtosecond laser energy with very low per-pulse energy load. Each contact glass is also individually calibrated when attached to the laser device. Finally, the high pulse repetition rate of 500 kHz minimizes treatment time.

Advantages of SMILE over LASIK and PRK
1. More accurate and repeatable tissue removal Intrastromal lenticule procedures may bring advantages over LASIK and PRK as all of the potential errors associated with excimer laser ablation are avoided, such as stromal hydration, laser fluence projection and reflection losses, and other environmental factors. In SMILE, the incision is removed only by the accuracy of the femtosecond laser, which is not affected by any changes in environmental conditions. This accuracy is demonstrated by the 4.4 μm reproducibility of cap thickness. Therefore, it is likely that there will be less need for personalized nomograms to be used for different machines, locations, or surgeons.

2. Increased biomechanical integrity
Another potential benefit of SMILE is increased biomechanical stability. The absence of a flap and the fact that the stromal tissue is removed from within the stroma means that the anterior-most stromal lamellae remain intact after the procedure (except for the region of the small incision). This is in contrast to both LASIK, where the anterior stromal lamellae are severed by the creation of the flap and also by the excimer laser ablation, and PRK, where the anterior stromal lamellae are severed by the excimer laser ablation. Therefore, SMILE must leave the cornea with greater biomechanical strength than both LASIK and PRK as the anterior stroma is known to be the strongest part of the stroma, which has been elegantly demonstrated by Randleman et al. In their 2008 study, they measured the tensile strength of strips of stromal lamellae cut from different depths within the cornea and found a strong negative correlation between stromal depth and tensile strength. The anterior 40% of the intrastromal lenticule was found to be the strongest region of the cornea, whereas the posterior 60% of the stroma was at least 50% weaker.

But given the decreasing strength of stroma with depth, we also need to start thinking more in terms of tensile strength rather than simply in terms of residual stromal thickness, which is something that we have done by developing a postoperative tensile strength calculator based on the Randleman data. The model predicted that the postop tensile strength after SMILE was approximately 10% higher than PRK and 25% higher than LASIK. For example, the postoperative relative total tensile strength would be 60% for an ablation depth of 73 μm in LASIK (approximately ~5.75 D), 1.32 μm in PRK (approximately ~10.00 D), and 175 μm in SMILE (approximately ~13.50 D), translating to a 7.75 D difference between LASIK and SMILE for a cornea of the same postoperative relative total tensile strength.

The other factor is that no side cut is created in SMILE, which minimizes the corneal biomechanical change as fewer stromal lamellae are severed. This has recently been demonstrated in a study on cadaver eyes by Knox Cartwright et al. who found that the increase in strain was the same for a side cut only as a LASIK flap, whereas there was a very small increase in strain with the delamination cut only.

3. Reduction in postoperative dry eye
The other major potential advantage of the flapless micro-invasive SMILE procedure is the reduction in postoperative dry eye compared with that observed after PRK and LASIK. The cornea is one of the most densely innervated peripheral tissues in humans with the majority of the nerve bundles within the anterior stroma. These anterior nerves are cut by the microkeratome or femtosecond laser in LASIK and by the ablation in PRK, which results in dry eye symptoms. In SMILE on the other hand, the anterior stromal nerveplexus is disrupted significantly less since no side cut is created, which should result in fewer dry eye symptoms and a faster recovery of postoperative patient comfort. Indeed, studies have shown the faster recovery of corneal sensation after SMILE with recovery to baseline by three months compared with six to 12 months after LASIK.

Summary
In summary, with the introduction of the VisuMax femtosecond system it has become clinically feasible to now create refractive lenticules of proper regularity with sufficient accuracy to meet and probably exceed the accuracy of excimer laser tissue ablation for corneal refractive corrections. This enables José Ignacio Barraguer’s original concept of keratomileusis to be effectuated through...
PRESBYOND Laser Blended Vision: My solution of choice for presbyopia in emmetropic, myopic, or hyperopic patients

Dan Z. Reinstein, MD, MA(Cantab), FRCS, CRFCOphth, FEBO

Concept behind PRESBYOND Laser Blended Vision

The human visual cortical system is inherently capable of filtering spherical aberration. Spherical aberration occurs naturally in the human eye, increases naturally with age, and in fact increases naturally during accommodation. Introducing spherical aberration dissipates the retinal image focusing point, meaning that there is a wider range of distances where the focus is equivalent, although slightly reduced. However, while the retinal image may be degraded by the spherical aberration of the optical system of the eye, our brains filter this spherical aberration and produce a sharp, unaberrated image in our minds. Our approach, in essence, was to utilize the range of inherent spherical aberration neural processing capability of the human visual cortex as a dynamic process for spherical aberration correction.

Thus, the spherical aberration of the eye can be modulated on the cornea by LASIK to increase the depth of focus of the human visual system by working within the natural processing range of cortical image sharpening so as not to affect the quality of the perceived image in the mind. This increase in depth of field has been demonstrated by the better-than-expected distance vision in the near eye of treated patients targeted for a nominal refraction of ~1.50 D in the nondominant eye; the mean visual acuity was about 20/45 whereas 20/80 would be expected for a nascent ~1.50 D refraction.

Of course, if there is too much ocular spherical aberration, the visual cortex is no longer able to fully “process” the spherical aberration, and this results in aberration-related quality of vision symptoms. Our research led us to conclude that we could use spherical aberration modulation to increase the depth of field of the eye by approximately 1.50 D; increasing spherical aberration beyond this level results in overloading cortical filters, leading to a loss of contrast sensitivity. Therefore, spherical aberration modulation cannot be used to produce 3 diopters of accommodation and hence provide full presbyopic correction by itself without compromising safety.

The solution is to combine this 1.50 D of increased depth of field with a micromonovision to achieve good near vision, but with a lower degree of anisometropia than in traditional monovision. As with spherical aberration, monovision is also based on a natural process, that of neural binocular rivalry, summation and suppression (intocellular rivalry, not intracellular). This strategy creates a blend zone of vision between the two eyes at intermediate distances meaning that much less suppression is required compared to traditional monovision, and there is no dissociation but rather fusion between the images of each eye. In fact, patients retain a functional level of uncorrected stereovision—proving that they have binocular function. Therefore, this method provides a solution to the common limitations of traditional monovision including loss of fusion due to anisometropia, poor intermediate vision, poor distance vision in the near eye, reduced binocular contrast sensitivity, and reduced (or even broken) stereovision.

In PRESBYOND Laser Blended Vision a number of factors are considered including age, accommodative amplitude, preoperative wavefront, tolerance to anisometropia, and the amount of refractive error. The software then combines these factors to generate an ablation profile with the aim of leaving the patient with an appropriate level of spherical aberration in order to maximize the depth of field without compromising contrast sensitivity, stereovision, or night vision.

At one year after PRESBYOND Laser Blended Vision, binocular UDVA was 20/20 or better and
A (r)evolutionary step in multifocality:
Introducing the trifocal AT LISA tri 839MP

Multifocal approaches
Multifocal approaches require the patient to adjust to the unnatural situation of having to differentiate between two images in the same eye and require a significant increase in aberrations to achieve these two focal points, so it is not surprising that these procedures are associated with loss of contrast sensitivity and night vision disturbances and even best spectacle corrected vision. Multifocality has been induced in the cornea by discontinuous excimer laser ablation profiles, femtosecond cylindrical intrastromal keratotomy incisions or corneal inlays. Intracorneal multifocality by intracorneal lens implants has also been employed requiring either clear lens or cataract extraction. However, there have been significant improvements both in corneal and intracorneal lens multifocal solutions over the years, multifocality will always rely on the patient’s ability to adapt to this new and unnatural intraocular rivalry. Multifocal corneal treatment options are usually limited to a small range of refractive error and difficult to reverse, while intracorneal solutions involve the relatively higher risk of implant exchange procedures.

Pinhole inlay
A pinhole inlay technology has been available worldwide since 2005 and at the time of writing, is in final phase FDA clinical trials in the U.S. Implantation of this device deep into the corneal stroma in one eye produces increased depth of field, which can significantly improve reading vision in emmetropic or low myopic eyes with the advantage of retaining good distance acuity. However, the technique must be combined with LASIK for correction of presbyopia with ametropia. And since the pinhole mechanism inherently cuts down the amount of light entering the eye (and hence luminosity (along with contrast sensitivity to a certain degree)), it does not provide comfortable reading vision in low lighting conditions.

Summary
In summary, PRESBYOND Laser Blended Vision is a solution for presbyopia that in the presence of a patient who is physically a candidate for LASIK, meets all the goals of good binocular vision at all distances, minimizes any compromise in safety, contrast sensitivity, or night vision, and results in binocular vision with retention of functional stereo acuity. The procedure is immediately reversible by wearing spectacles, or a simple retreatment can be done using a standard ablation into the corneal stroma in one eye producing increased depth of field, which can significantly improve reading vision in emmetropic or low myopic eyes with the advantage of retaining good distance acuity. However, the technique must be combined with LASIK for correction of presbyopia with ametropia. And since the pinhole mechanism inherently cuts down the amount of light entering the eye (and hence luminosity along with contrast sensitivity to a certain degree), it does not provide comfortable reading vision in low lighting conditions.

Dr. Reinstein practices at the London Vision Clinic, London, and is affiliated with the Department of Ophthalmology, Columbia University Medical College, New York, and the Centre Hospitalier National d’Ophtalmologie, Paris. He can be contacted at dr@londonvisionclinic.com.
**Subjective refraction and defocus curves**

In terms of mean subjective refraction, the trifocal lens achieved a slightly better postoperative spherical equivalent than the bifocal—47% achieved emmetropia with the trifocal lens compared to 27% with the bifocal lens. This is extremely important, since multifocal lenses do not work if they don’t achieve emmetropia.

In terms of uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA), the trifocal IOL provides a clear advantage over the bifocal lens in the intermediate range. The near vision was slightly better with the bifocal IOL. However, Dr. Breyer speculates that the bifocal IOL’s near vision advantage may be an artifact of the small sample size, since the defocus curves do not reflect this result. The defocus curves indicate comparable near and far vision performance between the two IOLs, with an increased plateau at 70 cm (-1.5 D defocus) with the trifocal IOL—indicating high level intermediate visual acuity without loss of near and far.

Dr. Breyer thinks that it is necessary to introduce a new term in the MIOL world to evaluate a comparable MIOL performance. To describe MIOL capacity they integrated the area under the defocus curve ranging from -3.0 to 0.0 diopters. They chose this range due to the relevance of a patient’s visual routine.

**Light transmission**

Multifocals typically have problems with light transmission, leading to patients complaining about reading at night. The AT LISA tri 839MP increases the light transmission from older IOL generations, with 87% mean transmission over a wide range of pupil diameters.

Using a Ginsburg box, Dr. Breyer found that the two AT LISA IOL models provide photopic vision almost similar to the juvenile phakic eye. Mesopic vision dropped compared with the juvenile phakic eye, as it is typical for MIOLs, but Dr. Breyer did not find the drop as significant as with other MIOLs measured with the Ginsburg box. Clinically, the trifocal IOL patients did not complain about dim light reading vision as much as with other IOLs.

**Photopsia**

Returning to the question of photopsia, the AT LISA tri 839MP’s diffractive pattern features a different optical architecture compared to other MIOL. In order to see whether the new pattern reduces photopsia and enhances contrast sensitivity as intended, Dr. Breyer had patients subjectively evaluate their vision by software simulation. Given three different halo types—type 1 (T1), diffuse ring; type 2 (T2), spider web; type 3 (T3), grained ring—patients were asked to estimate individually the type of halo and corresponding size and intensity.

T1 halos had been the most common type of photopsia experienced by Dr. Breyer’s patients. However, with the AT LISA tri 839MP, patients described a new phenotype of halo—spider web without starburst, designated T2. Some patients still reported T1 halos, but bluish light sources were always associated with T2 halos. At any rate, compared with the AT LISA 809MP, the overall halo and glare intensity was very similar, with both IOLs causing very minor photopsia.

**Rhexis: Laser vs. manual**

Dr. Breyer and his colleagues also compared refractive outcomes between patients receiving the AT LISA 839MP but with different rhexis methods. They found that while there was no significant difference in postop spherical equivalent between laser-assisted and manual rhexis, there was a mild tendency toward myopia with laser-assisted rhexis. In terms of performance analysis, laser-assisted rhexis produced more “perfect” outcomes, while manual rhexis produced slight undercorrection.

**Experience**

At the end of their study, Dr. Breyer and his colleagues asked their patients to fill out questionnaires about their general and individual experiences with the IOL. The patients reported very high contentment with reading, intermediate, and far distance vision. They also reported not needing glasses almost 100% of the time for daily routines, bringing the idea of true spectacle freedom closer to reality.

Individual patients reported excellent vision for working all day at a computer, using vehicles under mesopic conditions—both reading the instrument panel and seeing far distance objects without glasses—and even reading instruction manuals or product information.

In Dr. Breyer’s experience, no other IOL has produced similar positive results, in terms of refractive outcomes and patient response. With the new AT LISA tri 839MP trifocal IOL, he can confidently say that the multifocal IOL glass is half full.

**References**


3. Dr. Breyer is chief surgeon of Breyer & Kaymaz Eye Surgery, Düsseldorf, Germany. He can be contacted at dr.detlev.breyer@gmail.com.
The complete anterior segment imaging solution

History of imaging and existing technologies
Imaging technology has come a long way since the first significant development in 1619, when Scheiner provided the first accurate description of the anatomy of the eyeball. He compared the eye to the known curvatures of glass balls. Data generated from advanced keratometry systems now available tells us about shape, curvature, elevation, and thickness.

Two of the most popular systems today are the Orbscan II (Bausch + Lomb, Rochester, N.Y.) and the Pentacam (Oculus, Wetzlar, Germany).

The Orbscan II uses a slit system combined with Placido disc imaging of the surface. During data acquisition, the system projects 40 slits onto the cornea, 20 on each side. This is done in a scanning fashion at an angle of 45 degrees, with the backscattered light captured by a digital camera. The system captures light from 240 points extracted from the slits that are then processed by the system’s software to calculate different variables, including anterior and posterior floats, keratometry, and corneal thickness.

However, surgeons need to be careful when interpreting maps from the Orbscan. The Orbscan II determines the shape of the cornea through curvature rather than elevation maps. The system works well for normal corneas, but abnormal situations or even post-refractive cases may result in spurious readings.

In contrast, Pentacam uses the Scheimpflug photography technique. The technique was devised in 1906 to enhance the quality of aerial photographs by taking several images from different angles. Using the Scheimpflug technique, the Pentacam takes images around the surface of the cornea from different angles, thus providing a better appreciation of elevation and depth. The latest version, the Pentacam HR, has improved resolution, with data processed from 138,000 points.

By working with proper elevation maps, the system allows surgeons to take a more detailed look at different parameters, allowing them to track the corneal thickness from the center of the cornea outward. This is particularly advantageous in post-refractive cases, especially when monitoring for ectasia, which necessitates more accurate monitoring of thickness than can be achieved with standard Orbscan topography.

The main issue with Scheimpflug photography is reproducibility: Any movement of the eye or errors in fixation during image capture will cause distortions in the final image and subsequent data.

All-in-one imaging
Visante omni, the latest imaging solution from Carl Zeiss Meditec Inc. (Dublin, Calif.), combines two already successful systems: the ATLAS Corneal Topographer, a reliable imaging system for anterior topography, and the Visante OCT, which measures and analyzes anterior and posterior elevation, pachymetry, and full-width anterior segment imaging.

The Visante omni fits the ATLAS and the Visante OCT onto the same workbench. The process begins with an image taken with the ATLAS. The system’s proprietary V-Trac Registration System precisely defines the corneal vertex. This precise corneal vertex registration ensures reliable corneal posterior topography. V-Trac Registration uses strict criteria to prevent potential misalignment.

Once the target—the corneal vertex—is acquired, a pachymetry module in the Visante omni system is used to measure the corneal thickness all the way around. The system then calculates anterior elevation data on the ATLAS and uses the corneal thickness map from the OCT to accurately determine posterior curvature and elevation.

The system thus provides comprehensive corneal analysis including anterior topography, pachymetry and relative pachymetry, and anterior and posterior elevations to improve detection of keratoconus. The ATLAS Pathfinder II software then classifies anterior topography into several categories using the Support Vector Machine algorithm and clinical database, giving surgeons a better idea of unusual corneal thickness values that may lead to suspicions of forme fruste keratoconus, enhancing patient selection and advancing diagnostic confidence.

The typical readout from the system provides the surgeon with white-to-white measurements of the steep Ks both on the anterior and posterior cornea, a relative pachymetry map based on a normative database, and a toric ellipse of the new corrected reading that can be changed to a different setting by altering the program software.

Clinical data
In order to see its accuracy, Jodhbir Mehta, BSc, FRCS Ed, FRCOphth, Singapore, conducted an intra-/interobserver study in which 40 patients with normal corneas were examined using the Visante omni system. The results were compared with standard machines available on the market. The parameters examined were anterior surface elevations, posterior surface elevations, Sim Ks, and aberation. The statistical data was analyzed using Bland-Altman analysis, typical when comparing two instruments. The mean bias was examined when comparing two values taken from different observers.

The data showed that the intra- and interobserver values were very accurate. The mean bias was very small, p-values high, and limits of agreement (LOAs) comparable for Sim Ks (intraobserver -0.012, p=0.7, LOA -0.38 – 0.36; interobserver 0.014, p=0.69, LOA -0.41 – 0.44), flat Ks (intra 0.018, p=0.5, LOA -0.31 – 0.35; inter 0.05, p=0.8, LOA -0.35 – 0.36), and anterior corneal curvature along the X-axis (intra 0.452, p=0.22, LOA -3.9 – 4.8; inter 0.04, p=0.9, LOA -4.0 – 4.12) and along the Y-axis (intra 0.114, p=0.74, LOA -4.4 – 4.2; inter -0.612, p=0.097, LOA -0.15 – 0.19).

Summary
Technological improvements in all types of refractive surgery, including cataract and laser-based procedures, call for more detailed analyses of corneas than surgeons have been used to with surface readings. Improvements in technology with regard to consistency between normal eyes and abnormal eyes provide surgeons with a whole range of detailed information with newer topography machines. By using the ATLAS together with the Visante OCT, the Visante omni system combines two well-established technologies to provide more information about the cornea.

Dr. Mehta is head of the corneal and external disease service and consultant in the refractive service, Singapore National Eye Centre (SNEC); head of the Tissue Engineering and Stem Cells Group, Singapore Eye Research Institute; and associate professor at Duke-NUS Graduate Medical School. He can be contacted at jodmehtha@gmail.com.