Why You Should Consider New Technologies

Surgeons discuss the implementation of new devices and procedures for laser vision correction.

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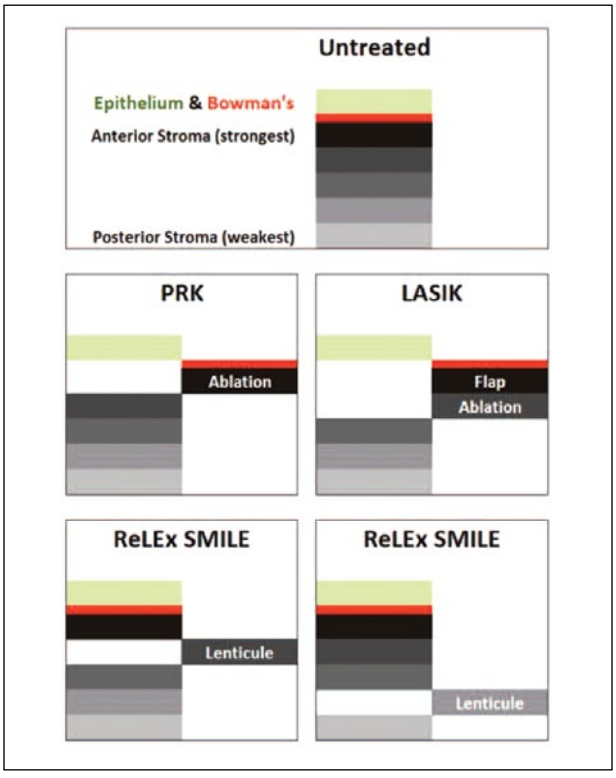
By Cati Albou-Ganem, MD

Surgical correction of myopia with a laser is a reliable, precise technique. The efficacy of this type of refractive correction has been demonstrated for a number of years. Complications are rare, but the most formidable and dreaded still today is corneal ectasia. However, current means of detection allow the preoperative identification of risky corneas if limits are properly established. These limits are based primarily on pachymetry of the central cornea and the calculated residual stromal thickness.

Surgical correction of myopia has recently evolved. One rather new technique is ReLEx smile (Carl Zeiss Meditec), in which refractive correction is achieved by creation of a lenticule that is removed through a small incision of only several millimeters. During ReLEx smile, the laser dissects an aspheric lenticule of predetermined power within the stroma to perform a refractive correction. The laser also creates the incision. The entire surface of the anterior and posterior faces of the lenticule is dissected and, thus, liberated from the surrounding stroma. The lenticule, whose diameter is an average of 6.5 mm and whose thickness is 16 µm per diopter of desired correction, is then extracted through the incision.



(Courtesy of Dan Z. Reinstein, MD, MA(Cantab), FRCSC, DABO, FRCOphth, FEBO)

Figure 1. The difference in strength of the remaining stroma after PRK, LASIK, and ReLEx smile is illustrated. The strength of the stroma remaining after ReLEx smile is greater than after PRK and LASIK. The intact Bowman layer also provides added strength. The two diagrams for ReLEx smile (bottom row) also show the even greater strength if the lenticule is removed from deeper within the stroma.

FIVE ADVANTAGES

ReLEx smile offers five primary advantages.

No. 1: This technique better maintains the biomechanics of the cornea compared with LASIK and PRK (Figure 1),[1] due to the absence of the flap and because the stromal tissue is removed from within the stroma. Therefore, the anterior part of the stromal lamellae and the Bowman membrane remain intact after the procedure, except in the region of the incision.

Randleman et al[2] showed that the cohesive tensile strength of the cornea is highest in the anterior 40% of the stroma, particularly in the portion adjacent to Bowman membrane; the posterior 60% has a cohesive tensile strength almost 50% weaker (33.3 g/mm vs 19.6 g/mm).

We now understand that the photoablation depth must be within the anterior third of the cornea in order for most of the stromal resistance to remain intact. This is espe-

cially the case for LASIK, in which the thickness of the flap is added to the depth of the photoablation to calculate the residual stromal thickness. When refractive surgery is performed by extracting a refractive intrastromal lenticule through a small incision, the concept of residual posterior stromal thickness does not apply because the anterior cornea is not affected except at the incision site.

Roberts et al[3] showed that ReLEx smile created less mechanical insult to the anterior cornea and, thus, resulted in a central surface stress that was closer to the unoperated state. Also, the central stress at the level of the residual stromal bed was closer to the stress pattern in an unoperated eye. In another study conducted by Abdalla,[4] 60 eyes underwent LASIK or ReLEx smile for myopic corrections between -3.00 and -5.00 D. Corneal hysteresis (CH) and corneal resistance factor (CRF) were measured at 3 months preoperatively and 3 months postoperatively; the mean change in CH was -6.7% in the ReLEx smile group and -17.4 % in the LASIK group without correlation to percentage of corneal tissue removed, the optical zone, or patient age. Mean CRF decreased 9.7% in the ReLEx smile group and 22% in the LASIK group.

These studies suggest that the safety of refractive surgery should be based not on the amount of ablation but rather on the quality of postoperative corneal cohesive tensile strength. Given the decreasing strength of the stroma with decreasing depth, we must start thinking more in terms of residual tensile strength rather than residual stromal thickness.

No. 2: Femtosecond laser cuts are reproducible and precise, with a standard deviation of 5 to 10 µm.

No. 3: Femtosecond lasers do not use gas and are not subject to variations in environmental conditions (eg, temperature and humidity) like the excimer laser. Therefore, potential inaccuracies related to weather and hydration of the stroma are avoided.

No. 4: The location of the lenticule within the stroma avoids cutting the long posterior corneal nerves and, therefore, reduces the risk of postoperative dry eye.

No. 5: Postoperative symptoms are generally shortened with ReLEx smile, lasting only 2 to 3 hours.

All of these advantages have prompted me to use ReLEx smile instead of LASIK for the correction of myopic refractive errors.

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By Arthur B. Cummings, MB ChB, FCS(SA), MMed(Ophth), FRCS(Edin)

I am not sure that future outcomes with laser vision correction can surpass what has been achieved recently with modern technology. I am familiar with the WaveLight laser technology (Alcon) and can speak only to this, but if you consider that we currently achieve refractive outcomes within ±0.50 D of target in 92% of myopia cases, then there is not much room for improvement, especially considering that the standard deviation for a subjective refraction is 92% within ±0.50 D.[1]

However, there is more to refractive surgery than predictability. There is also quality of vision, a metric that is lacking in everyday practice. In studies, contrast sensitivity is used to measure quality of vision, but it is simply too cumbersome for routine clinical use. Devices such as the HD Analyzer (Visiometrics) have the ability to more readily tell us about quality of vision.

The wavefront-optimized profile of the WaveLight laser works so well that, in my hands, in only 15% of cases do we use customized ablation modalities such as wavefront-guided, topography-guided with the Topolyzer Vario Placido-disc topographer (Alcon), or Scheimpflug-based with the Oculyzer (Alcon). In 2010, outcomes with a ray-tracing profile from a three-center European trial were published,[2] and these results surpassed all others achieved in earlier studies of this platform. Plans are under way to make the ray-tracing profile commercially available.

Recently, the US Food and Drug Administration (FDA) cleared topography-guided LASIK for use in the United States. The results obtained in clinical trials were outstanding,[3] as the investigators went to great lengths to select patients who were ideal candidates for this technology. For example, the topographic astigmatism correlated well with the refractive astigmatism. When attention is paid to details such as these, the results can be more powerful than what we currently consider the state of the art. In my opinion, therefore, the only way to make LASIK or surface ablation better is via more sophisticated ablation profiles such as the ray-tracing profile.

Moving away from LASIK, there is growing interest in intrastromal lenticular extractions such as ReLEx flex and ReLEx smile. These procedures may not currently provide better visual results than LASIK, but they may offer biomechanical benefits. This is an area in which improvements can still be made. Time will also tell whether performing flash corneal collagen crosslinking (CXL) at the end of LASIK provides biomechanical or other benefits.

If innovation stops now, we know that laser refractive surgery will not improve further. If innovation continues, I

believe that there will be further improvements; however, these advances will get incrementally smaller, thanks to the fact that laser refractive surgery is currently performed to such a high standard on modern laser systems.

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By Simonetta Morselli, MD; and Antonio Toso, MD

Anterior segment surgeons should consider implementing femtosecond laser technology, as both corneal refractive and cataract surgery can benefit from its use. In eyes in which premium IOL implantation with either a multifocal or toric lens is planned—whether in cataract surgery or refractive clear lens exchange—the surgeon's goal is to create a perfect capsulorrhexis. Performing femtosecond laser-assisted lens surgery can help us to achieve a perfect, centered capsulorrhexis in these cases. The crucial point of phacoemulsification is the rhexis, which should be central, curvilinear, and continuous. With the femtosecond laser, the capsulorrhexis can be placed exactly where the surgeon wants, which is quite different from our past capabilities.

Additionally, the femtosecond laser can segment the nucleus into smaller pieces so that less phaco energy is needed to remove the pieces. In some cases, especially in clear lens exchange, only aspiration is necessary to complete this step. In our practice, we use a dual-linear footpedal system for phaco cataract surgery, and vacuum is delivered by depressing the pedal. Ultrasound can be delivered at any level of vacuum by turning the footpedal in the lateral direction. In our opinion, this is the best technique for removing the laser-segmented cataract pieces because it allows us to lower the level of energy used.

Further, limbal and corneal incisions for lens surgery are performed precisely with the femtosecond laser. Incision size is perfectly calculated, as is length and position. This precision can help the surgeon to accurately predict the postoperatively induced astigmatism, especially in cases in which a premium IOL is to be implanted. With the femtosecond laser, complications such as vitreous loss are reduced because most steps of the procedure are performed by the femtosecond laser.

Femtosecond laser technology is also valuable for LASIK. Femtosecond laser corneal flaps are perfect in both diameter and thickness, which is the most significant advantage of this technology. With mechanical microkeratomes, the predicted thickness of the flap was not precise (±20% variation could be expected). This affected the thickness of the residual stromal bed to be treated by the excimer laser. This variability was strongly associated with postoperative ectasia after LASIK. With femtosecond laser technologies, this problem has been eliminated because the flap thickness is perfectly predictable.

More recently, the possibility to perform intrastromal corneal treatment to correct refractive errors has been developed. In treatments known as ReLEx smile, the femtosecond laser is used to create a small lenticule that is removed from the inner corneal stroma to correct myopia or hyperopia and mild astigmatism through a small 2.2-mm incision without opening a corneal flap. We have been performing this technique for the past year and have achieved nice results in terms of refractive outcomes, patient recovery, and visual and anatomic results.

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One of the latest technologies we have added to our armamentarium for laser vision correction is the most recent version of the Amaris (1050RS; Schwind eye-tech-solutions). This 1,050-Hz laser has a unique eye-tracking system that follows the eye in every direction and predicts where laser pulses will be placed every seventh pulse—what Schwind refers to as the *seventh dimension*. Predictive algorithms have been applied to many systems outside ophthalmology, including the most advanced Nikon cameras that have a predictive autofocus system. Google is also

working on predictive eye-tracking systems for use in computers and, of course, Google Glass.

The performance of the seven-dimensional eye tracker has been outstanding, and we have had no problems with ablation centration using the device's rapid ablation speeds. A 1.00 D myopic treatment at a 6-mm optical zone takes 1.3 seconds. This makes the treatment period extremely short and improves patient comfort without loss of accuracy. The rapid ablation speed of the Amaris has also helped significantly reduce the ablation time for transepithelial PRK (trans-PRK). Trans-PRK previously required a much longer ablation time because the epithelium was removed using the excimer laser; with the 1,050-Hz laser, the time for ablation is reduced by 40%.

Another technology we have recently added to our practice is LASIK Xtra (Avedro). With the use of Avedro's KXL System, we have been pleasantly surprised to find that our results with LASIK for high myopia (-8.00 to -18.00 D) are more accurate and stable. Adding Avedro KXL treatment—with its short application time of 45 seconds for 0.25% riboflavin (in saline) and accelerated ultraviolet-A CXL at 30 mW/cm^2—has not increased our total LASIK treatment time significantly. In our technique, the riboflavin is allowed to soak into the stromal bed before the LASIK flap is replaced. After flap replacement, accelerated CXL is performed. In the past, we used to wait 3 minutes for the flap to adhere to the stroma; now during this period, we perform our accelerated CXL. Therefore the addition of KXL has added no more than 1 minute to our normal LASIK procedure time.

Our results have been so impressive that we are lowering our criteria for LASIK Xtra to include all myopic corrections above -6.00 D, and, upon patient request, we will perform LASIK Xtra on even lower powers. We are now investigating and comparing the results of LASIK Xtra with those of standard LASIK for corrections below -6.00 D. I believe that these results will also be improved and that LASIK Xtra may become standard of care in the future. Whether LASIK Xtra prevents corneal ectasia will be followed with great interest, but this will require many thousands of cases and many years of follow-up. Currently, the observed improvement in accuracy and stability is a good indirect indicator that we are strengthening and stabilizing the cornea.

Laser vision correction will continue to improve as better hardware and software are developed, with the ultimate aim of making procedures quicker, safer, and more accurate than ever before. ■

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