The cornea plays an integral part in maintaining visual quality as well as in the overall health of the eye. A healthy cornea is smooth, transparent, and strong, but it is also sensitive. Many of the refractive surgery techniques used today alter the cornea’s shape to produce a refractive change, reducing the need for spectacle correction. However, in the presence of an irregular or thin cornea, excimer laser surgery may not be advisable. CRST Europe invited Jorge L. Alió, MD, PhD, and colleagues, to detail the challenges of surgical intervention in these patient populations.

Correction of the Irregular Cornea
Customized corneal wavefront-guided excimer laser surgery.

By Jorge L. Alió, MD, PhD; and David P. Piñero, PhD
Induction of higher-order aberrations is common after surface and stromal ablation. It can also be induced after other corneal refractive procedures using methods other than the excimer laser, such as radial keratotomy and conductive keratoplasty. Excimer laser refractive surgery has improved due to developments in lasers and the introduction of newer ablation profiles. The objectives of these developments are to generate ablation profiles with minimal induction of aberrations and to create lasers that correct all higher-order aberrations precisely.

Wavefront-guided ablations are now the preferred solution for eyes with significant higher-order aberrations due to previous refractive surgery with classic ablation algorithms or other corneal procedures. Specifically, corneal wavefront-guided ablation is the key for improving visual performance in highly aberrated corneas, because of the refractive importance of the anterior corneal surface and the more precise sampling analysis obtained with corneal topography.

ANALYZING ABBERRATED EYES
Topographic systems analyze more than 6,000 data points to produce exhaustive clinical analysis. However, ocular wavefront sensors and aberrometers, such as Hartmann-Shack devices, have limited capacity to analyze highly aberrated eyes due to crowding or superimposing of the light spots or the assumption of flat slope for each analyzed portion of the wavefront.

Corneal wavefront-guided refractive surgery can be an effective surgical technique, especially for restoring quality of vision in patients with high levels of higher-order aberrations after previous keratorefractive procedures. In these highly aberrated corneas, the first corneal surface is the most important source of optical errors. The air-cornea interface

is the main contributor to the total power of the eye, due to the large difference in refractive indices between air and cornea. Therefore, minimizing corneal aberrations significantly affects visual quality. Retreatments in these aberrated cases are commonly performed in the stromal bed, after lifting the existing flap if LASIK was previously performed. These retreatments are safe and effective. Another option is to create a new flap under the old cut; however, the new interface is another source of optical errors and limits the effect of refractive and aberrometric correction.

After unsuccessful LASIK, in retreatment of a highly aberrated cornea, the main limitation is normally the corneal thickness. The residual stromal bed is not thick enough for additional tissue ablation, because of previous large refractive error correction or multiple retreatment. Corneal wavefront-guided surface ablation is an option for retreatment, even in highly aberrated eyes, after previous LASIK and in eyes with insufficient pachymetry for stromal bed retreatment.

**CONCLUSION**

Several excimer laser platforms include specific software for corneal wavefront-guided ablation design, such as the ORK-CAM (Schwind eye-tech-solutions, Kleinostheim, Germany) software. With these systems, customized treatments can be generated from the corneal elevation data derived from corneal topography. Corneal wavefront-guided ablations can be created for the Esiris and Amaris excimer lasers (both by Schwind Eye-Tech-Solutions) using the corneal topography data obtained with Placido-disc or Scheimpflug-based systems.

**Approaching Excimer Laser Surgery in the Thin Cornea**

**Thin preop central corneal thickness alone is not considered a contraindication for corneal refractive laser surgery.**

By Jorge L. Alió, MD, PhD; and Miguel A. Teus, MD, PhD

Corneal ectasia is one of the most feared complications after refractive surgery. Identification of corneas at risk for ectasia is, therefore, paramount in the preoperative evaluation. Randleman et al. recently published risk factors for ectasia present in eyes that developed the complication after LASIK. They found that the most significant predictor was the presence of topographic abnormalities (Figure 1), even when compared with preoperative central corneal thickness (CCT). The average preoperative CCT in eyes that developed ectasia was 521 µm, eyes with preoperative topographic abnormalities developed ectasia despite normal CCTs.

**AVERAGE CCT**

The question arises: What is a thin cornea? Statistically, a cornea may be considered abnormally thin if the CCT is thinner than the average CCT in the general population minus two standard deviations. According to our data from a healthy Spanish population, the average CCT is 548.2 ± 30.7 µm, meaning the inferior limit of normal CCT is 488 µm. Assuming that this parameter has normal distribution, corneas thinner than 488 µm occur in 2.5% of the population.

Even in patients with a normal CCT, the only fear is that the ablation may produce an unacceptable residual stromal bed (RSB) thickness of 250 µm or less. If the surgeon can guarantee preservation of a thick enough RSB, it is safe to proceed with corneal refractive surgery if the corneal topography is normal. Therefore, it is important to choose patients with an adequate preoperative CCT. In the literature, the accepted cutoff is approximately 500 µm. Although this cutoff is perhaps incorrect statistically, we have also chosen to establish our preoperative CCT cutoff at 500 µm.

Evidence suggests that LASIK² and surface ablation with³ and without mitomycin-C⁴ do not induce ectasia when performed in corneas thinner than 500 µm and normal preoperative topographies. However, the thicker the LASIK flap, the thinner the RSB for the same degree of corneal ablation. Thus, it seems wise to favor the use of surface ablation in these eyes, unless a thin flap and an adequate RSB thickness can be guaranteed, such as with the use of sub-Bowman’s keratomileusis (SBK). This technique is safe and effective in the correction of myopia; use of a flap between 90 and 100 µm does not increase the complication rate.

When the expected RSB approaches 250 µm, it is better to perform surface ablation with intraoperative mitomycin-C if the ablation depth is greater than 50 µm. Mitomycin-C is applied to minimize the risk of haze. This approach, due to the absence of a flap, dramatically increases the RSB thickness for the same amount of ablation. Outcomes are comparable in terms of effectiveness and safety to SBK, although the visual acuity recovery is much slower.
We have followed patients with preoperative CCTs thinner than 500 µm for 10 years, with no cases of ectasia. We have evidence of a similar safety profile, although at much shorter interval (15 months), after surface ablation with the adjunctive use of intraoperative mitomycin-C.

We believe that preoperative corneal topography is a sensitive indicator of the tendency to develop ectasia. An abnormal topography, even with only subtle signs of abnormality, is a marker for the tendency to develop ectasia after LASIK. This is true no matter what the CCT of the eye is. A thin preoperative CCT alone cannot be considered a contraindication for corneal refractive laser surgery, provided an adequate RSB is preserved. In cases in which an adequate RSB cannot be guaranteed, surface ablation is an acceptable alternative when intraoperative mitomycin-C is used.

Jorge L. Alió, MD, PhD, is a Professor and the Chairman of Ophthalmology at the Miguel Hernandez University, Alicante, Spain, and the Medical Director of Vissum Corp., Spain. Professor Alió states that he has no financial interest in the products or companies mentioned. He may be reached at tel: +34 96 515 00 25; e-mail: jlalio@vissum.com.

Miguel A. Teus, MD, PhD, is a Professor of Ophthalmology, the Universidad de Alcalá de Henares, Madrid, Spain, and practices at Vissum Corp., Spain. Professor Teus states that he has no financial interest in the products or companies mentioned. He may be reached at e-mail: mteus@vissum.com.