Surface ablation techniques avoid the unwanted side effect of corneal weakening due to flap creation. At our center, we perform LASEK\(^1\) and epi-LASEK\(^2,3\) with the Amaris (Schwind eye-tech-solutions, Kleinostheim, Germany). These treatments provide the surgeon with complete control of corneal aberrations and are painless in nearly every case. Quality of vision is restored within 10 days and remains stable over the long term.

**ABERRATIONS MANAGEMENT**

The Amaris offers different levels of aberration control (Figure 1) in the form of specifically designed ablation profiles. It also has the option of corneal or ocular wavefront treatment planning and centration aids (Table 1).

**Ablation profiles.** The aberration-free profile is our first choice for primary treatments. This aspheric aberration-neutral profile adds some aspheric characteristics to balance the induction of spherical aberration. It also incorporates a multidynamic aspheric transition zone (depending on planned refraction and optical zone size); compensation for aberration and focus shift due to tissue removal; pseudomatrix-based spot positioning (spot overlapping is a major parameter, and the spot spacing is small compared with the spot width so that multiple spots overlap, contributing to the ablation at each corneal location); enhanced compensation for loss of efficiency; and intelligent thermal effect control.

**Corneal wavefront.** Typically used for secondary procedures or retreatments, this treatment plan is developed using a corneal-wavefront–customized aspheric profile based on corneal ray tracing. Using the Keratron Scout videokeratoscope (Optikon Corp Ltd., Kitchener, Ontario), topography and corneal wavefront are analyzed up to the seventh order, and the corneal topography is calculated.

In corneal wavefront analysis, the type and size of any optical error on the anterior corneal surface are registered to allow selective correction at their origin—the anterior corneal surface. Corneal wavefront provides individualized ablation of the cornea. Additionally, the treatment zone is not limited by pupil size, accommodation does not influence the measurements, and forcing a fixed asphericity quotient (Q) is avoided. Instead, this strategy employs a dynamic postoperative expected asphericity quotient.

**Ocular wavefront.** We use this treatment plan sporadi-
It is developed using an ocular-wavefront–customized aspheric profile based on Hartmann-Shack sensing. The high-resolution measurements (more than 800 points for a 7-mm pupil) describe the entire eye.

**Centration aids.** Two centration references—pupil center and corneal vertex—are detectable and measurable. Centering the treatment on the pupil allows the surgeon to minimize the size of the optical zone. The pupil center of a patient who fixates properly defines the line of sight.

The corneal vertex, in different modalities, is the second choice for the centration reference. In perfectly acquired topography, if the human optical system were truly coaxial, the corneal vertex would represent the corneal intercept of the visual axis. Although the human optical system is not truly coaxial, the cornea is the main refractive surface, and the corneal vertex is a stable morphologic reference. Ablations can be centered using the pupillary offset or the distance between the pupil center and the normal corneal vertex, which corresponds to the angle between the line of sight and the visual axis (Figure 2).

For aspheric or nonwavefront-guided treatments, the most appropriate centering reference is the corneal vertex. For wavefront-guided treatments, in which a more comprehensive data set from the patient diagnosis is used, including aberrations, the most appropriate centering reference is the entrance pupil as measured in the diagnosis.

Due to the smaller angle kappa in eyes with myopia, centration issues are less apparent. However, they can still have a significant effect; a pupillary offset of 0.25 mm is sufficient to be responsible for differences in aberrations.

For myopia, we prefer aberration-free treatments centered on the pupil when the pupil center differs by less than 0.1 mm from the corneal vertex, and we prefer to center the treatment on the corneal vertex when the pupil center differs by more than 0.1 mm and less than 0.5 mm from the corneal vertex. For hyperopia in combination with astigmatism, we prefer to use corneal wavefront treatment planning when the pupil center differs by more than 0.5 mm from the center of the corneal vertex.

**OPTICAL ZONE**

Large optical zones with smart blend zones help to avoid edge effects, especially in eyes with coma and
spherical aberration. Generally, optical zone size should be at least the size of the scotopic pupil diameter plus twice the pupil-vertex offset plus the eye-tracker resolution. The optical zone should normally be at least 7.0 mm and correspond with the mesopic pupil diameter; we never go below 6.5 mm. In hyperopia, an optical zone of 7.5 mm is preferable to minimize the risk of regression and halos at night; we never go below 7.0 mm. When necessary, we protect the hinge with a spatula.

Differences between effective and planned optical zones are greater for smaller planned optical zones and larger corrections.\(^5\) Planned optical zones larger than 6.75 mm result in effective optical zones at least as large as the planned optical zone. For optical zones smaller than 6.75 mm, a nomogram should be applied (Figure 3).

**EPI-LASEK**

Epi-LASEK, a technique we described in 2008,\(^2\) differs from LASEK in the use of an epikeratome to separate the epithelium. We prefer epi-LASEK because the epithelium is easily separated, excellent hinge width (nasal hinge) is achieved, and it is easier to put the epithelium back in place than it is with LASEK or epi-LASIK. The use of mitomycin C significantly decreases subepithelial haze.\(^6\)

For pupils larger than 8.0 mm, we place a limit of -4.00 to 1.50 D on the treatment spectrum for epi-LASEK.

In eyes with myopia, the central residual corneal thickness must be at least 350 µm, including the epithelium. In eyes with hyperopia, the peripheral residual stromal thickness should be thicker than in the center.

The postoperative corneal curvature should be at least 32.00 D. Beware of preoperatively flat corneas (ie, 40.00–42.00 D), because a significant step in the transition zone might result after a high correction.

**TRANSEPITHELIAL PRK**

We use transepithelial PRK combined with corneal wavefront for retreatments after radial keratotomy or corneal transplantation.\(^7\) This approach is also used in eyes with haze, scarred corneal tissue, keratoconus after crosslinking, and whenever a difficult epithelial flap is expected or when the epithelium covers irregularities of the corneal stromal tissue.

We sequentially perform a wavefront-guided aspheric ablation profile followed by a defined epithelial thickness profile, without masking fluid, to remove residual epithelium. We are able to achieve this as a single-step procedure with the Amaris, which optimizes the amount of epithelial tissue to avoid the myopic-like correction (about -0.75 D).

Transepithelial PRK treats refractive-therapeutic problems by superimposing a defined epithelial thickness profile (approximately 55 µm at the center, 65 µm at the periphery, and 4 mm radially from the center) with aspheric ablation profiles. The system analytically creates a single ablation volume, which is broken into laser pulses sorted spatially and temporally in a pseudo-random fashion. There is also a pseudo-sequentialization of the wavefront-guided and epithelial thickness profile components, but both components elapse without pause.

In transepithelial PRK, the epithelium is ablated with the Amaris laser system. This is the only surface treatment in which the eye does not come in contact with an instru-

---

Figure 3. (A) Effective optical zone versus achieved defocus correction. (B) Effective versus planned optical zone.
ment. Both the epithelium and the stroma are ablated in a single procedure, decreasing the overall treatment time and minimizing the risk of corneal dehydration.

In a series of therapeutic patients, we noted a remarkable decrease in corneal aberrations at a 6-mm optical zone. Residual defocus averaged about -0.60 D, and residual cylinder about 0.90 D. Seventy-one percent of patients were within 1.00 D of the target correction for both defocus and astigmatism. No hyperopic shift was observed. The mean decrease in astigmatism was 78%, representing a moderate undercorrection of astigmatism.

CONCLUSION
In our experience, the percentage of eyes with UCVA of 20/32 or better after transepithelial PRK is 60%, and 20% achieve UCVA of 20/20 or better. Forty-seven percent of eyes gained 2 or more lines of BCVA, and 23% showed an increase of more than 4 lines. Despite large magnitudes of defocus, astigmatism, and higher-order aberrations (HOAs) in eyes with refractive-therapeutic problems after previous radial keratotomy or keratoplasty, HOAs were reduced with simultaneous aspheric wavefront-guided transepithelial PRK profiles using the Amaris.

Samuel Arba-Mosquera, MSc, practices at the Grupo de Investigación de Cirugía Refractiva y Calidad de Visión, Instituto de OfalmoBiología Aplicada, University of Valladolid, Valladolid, Spain. He is an employee of Schwind eye-tech-solutions, Kleinostheim, Germany. He may be reached at e-mail: Samuel.Arba.Mosquera@eye-tech.net.

Massimo Camellin, MD, is the Health Director for SEKAL Rovigo Microsurgery Center, Rovigo, Italy. Dr. Camellin states that he has no financial interest in the products or companies mentioned. He may be reached at e-mail: cammas@tin.it.