Customized Ablation Profiles in the Modern Era

The area that has seen the greatest development in recent years is presbyopic correction.

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LASIK in 2014 is different from what it was 10 years ago. Microkeratomes and femtosecond lasers have evolved to a stage at which customized LASIK flaps can be tailored to fit the ablation profile, and the predictability of the planned flap thickness is on the order of microns, with a standard deviation of about 7 µm. This article, however, is about the advances in excimer laser ablation profiles.

THE EARLY DAYS

The first ablation profiles, based on Munnerlyn's work,[1] did a reasonably good job of correcting lower-order aberrations (LOAs; ie, sphere and cylinder). However, they often induced higher-order aberrations (HOAs; ie, spherical aberration and coma) in the process, especially with larger corrections. In 1999, WaveLight (now Alcon) released an aberration-free wavefront-optimized profile that aimed to correct LOAs without introducing HOAs. Although this major breakthrough in ablation profiles yielded good results in terms of quality of vision—including night vision—that had not been seen before, additional tools were required to treat patients with preexisting HOAs.

Wavefront-guided treatments based on either the Hartmann-Shack or Tscherning principle were developed shortly thereafter, around 2001, as a means to address preexisting HOAs. In the FDA study for clearance of the WaveLight Allegretto laser (Alcon), wavefront-guided treatments were demonstrated to reduce HOAs in eyes with more than 0.40 µm of preexisting error.[2] On occasion, however, corneal aberrations were too high to allow a wavefront measurement. The only way to correct these eyes would be using corneal data to drive the treatment; hence, topography-guided ablations were introduced, first Placido disk driven in 2004 and subsequently Scheimpflug driven in 2005.

The final frontier in ablation profiles around this time was the concept of asphericity: the user could predetermine the aspheric target of the treatment. The array of profiles in this aspheric category was used by surgeons mainly to improve their outcomes with presbyopic solutions, as it allowed them to select the most appropriate aspheric treatment for each patient. Today's leading high-frequency flying spot lasers still share these traits of being fundamentally aberration free and then having the customized ablation profile built on top of the aberration-free profile. Additionally, the Amaris 1050RS laser (Schwind eye-tech-solutions; not available in the United States) has a profile that can include or exclude aberrations, providing users with even more options to fine-tune an ablation according to a patient's specific wishes or needs.

RAY-TRACING TREATMENTS

If there was one thing missing, however, it was a profile that would take all these data into account and deliver the best result regardless of an eye's individual characteristics. Typical challenges include refractive unpredictability with highly aberrated eyes undergoing topography-guided treatments and less complicated eyes that were simply highly myopic.

The introduction of ray-tracing treatments helped to address this issue. These ablation profiles are calculated on a virtual eye model for each patient, created with his or her specific ocular parameters, including corneal dimensions and axial length. Prior to this time, all ablation profile calculations used Gullstrand's model eye and assumed a keratometry (K) reading of 43.00 D and an axial length of 24 mm in generating the ablation profile. This development of ray tracing in ablation profiles has led to increased predictability and better outcomes.[3] The benefits are especially apparent in eyes that deviate from the Gullstrand model.

<table>
<tr><th colspan="5">TABLE. LASER VISION CORRECTION STRATEGIES FOR PRESBYOPIA</th></tr>
<tr><th></th><th>Presbyond</th><th>Supracor</th><th>PresbyMax</th><th>IsoVision</th></tr>
<tr><td>Targets (D)</td><td>Plano / -0.90</td><td>-0.50 / -0.50</td><td>Plano / -0.90</td><td>Plano / Plano</td></tr>
<tr><td>Myopia</td><td>95% 20/20 / J2 (n = 272)</td><td></td><td rowspan="3">82% 20/20 UCDVA (n = 64)

89% J2 (n = 64)</td><td rowspan="3">82.4% distance VA efficacy (n = 200)

92.6% near VA efficacy (n = 200)

Three separate multicenter clinical trials to commence shortly (n = 400)</td></tr>
<tr><td>Hyperopia</td><td>77% 20/20 / J2 (n = 222)</td><td>96% 20/25 UCDVA (n = 46)

91% 20/25 UCNVA (n = 46)</td></tr>
<tr><td>Emmetropia</td><td>95% 20/20 / J2 (n=292)</td><td></td></tr>
<tr><td colspan="5">Abbreviations: VA, visual acuity; UCDVA, uncorrected distance VA; UCNVA, uncorrected near VA.</td></tr>
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PRESBYOPIA-CORRECTING PROFILES

The area that has seen the greatest development during the past few years is in presbyopia-correcting ablation profiles. Previously, a monovision approach could be used, with nonpresbyopic profiles targeting distance vision in one eye and reading in the other. Now, newer profiles such as the IsoVision (property of Frederic Hehn, MD, of Vandoeurve, France; not available in the United States) and Supracor (Bausch + Lomb Technolas; not available in the United States) can correct each eye to distance emmetropia (or -0.50 D in the case of Supracor) and also provide the patient with good near vision in each eye. These profiles do this by creating a hyperprolate cornea, so that the eye does most of the work, and the brain takes input equally from both eyes.

There are other strategies that use presbyopic profiles alongside forms of mini-monovision so that both the optics and grey matter contribute to the final visual product. Presbyond Laser Blended Vision (LBV; Carl Zeiss Meditec; not available in the United States) and PresbyMax (Schwind eye-tech-solutions; not available in the United States) are examples.

The amount of induced postoperative anisometropia varies among these available strategies (Table). The greatest amount is found in traditional monovision, in which the nondominant eye is corrected to a target between -1.00 and -2.00 D. With PresbyMax and Presbyond LBV, the correction in the nondominant eye is close to -1.00 D; however, the perceived difference between eyes is smaller due to increased spherical aberration. With Supracor, both eyes are targeted for -0.50 D, and, because of increased depth of field due to the increased spherical aberration, distance and near vision are both satisfactory. With IsoVision, emmetropia is targeted in both eyes, and the reading add is lasered on top of the distance correction using one of the asphericity profiles.

Despite the success of these profiles for carefully selected patients, most surgeons who perform corneal laser surgery to correct presbyopia would admit that, ultimately, the best solution for presbyopia is likely to be a lens-based procedure.

CONCLUSION

If one considers that the first LASIK procedure was performed almost 25 years ago using Munnerlyn's formula as the ablation profile,[1] it is encouraging to see how far we have collectively come toward truly improving our patients' quality of vision without glasses. In carefully selected cases, older presbyopic patients can now also achieve satisfactory corneal solutions for distance and near vision without glasses. ■

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