A Personalized Aspheric Treatment for Myopia

This new treatment did not induce aberrations in a clinical trial.

BY JAY DERMOTT, DOpt

n the short but eventful history of laser vision correction, a pattern of retrospective analysis followed by application of lessons learned has emerged. In the area of treatment algorithms, a path can be traced from initial treatments that sought only to replicate the correction achieved with spectacles to the modern idiom in which we are able to provide vision enhancement.

The first generation of wavefront-guided treatments was introduced to provide a solution for the small number of patients who experienced night-vision problems. Science borrowed from science, as it tends to do, and, incorporating the optical principles used in telescopes and microscopes, wavefront-guided treatment produced better results. However, interactions between the individual higher-order aberrations (HOAs) were not considered in this generation of wavefront.

The work of Scott MacRae, MD, and Geun Young Yoon, PhD, of Rochester, New York, improved the treatment algorithm of the Zyoptix z100 excimer laser platform (Technolas Perfect Vision GmbH, Munich, Germany), by addressing the trend toward overcorrection that many surgeons had seen with the first-generation Zyoptix wavefront treatment. What has subsequently become known as the Rochester Nomogram has resulted in improvements in accuracy and postoperative UCVA outcomes. Nevertheless, scientific analysis has now identified one more way to make the treatment better.

AVOID INDUCING ABERRATIONS

The image quality produced by optical systems, from spectacle lenses to telescopes, has long been linked to the asphericity of the surfaces used in those systems. In the early 1900s, Moritz von Rohr submitted a patent for an aspheric spectacle lens design on behalf of Carl Zeiss Meditec (Jena, Germany). What was evident in the world of spectacle lens design has been carried over to the field of contact lenses, where it was found that more closely following the corneal profile has both optical and physiologic benefits.

Holladay established that changes in corneal asphericity occur routinely following laser refractive surgery, and soon afterward Anera et al published an equation to predict the amount of asphericity induced by a refractive treatment. Fundamentally, the goal of any refractive procedure is to treat existing aberrations without inducing new ones. Lapid-Gortzak reported favorable outcomes for myopic treatments using an algorithm designed to reflect the innate level of corneal asphericity in the postoperative corneal profile.

A treatment that corrects one problem at the cost of inducing another, perhaps equally disabling, is unacceptable. The ophthalmic laser industry has searched for methods of improving surgical outcomes, starting with increasing the optical zone size of treatments and culminating with the means to treat HOAs. However, not all HOAs are equal in their effect on postoperative quality of vision. Third-order aberrations (ie, trefoil and coma) and spherical aberration are most heavily implicated in the denigration of visual quality.

Hersh and others have described how unwanted spherical aberration might be induced when the normally prolate cornea is rendered more oblate by steepening its periphery during myopic treatments. However, the laser beam strikes the corneal periphery obliquely,
reducing this effect. Hersh also described how to eliminate this phenomenon by applying more laser pulses while moving away from the center and into the blend zone, compensating for the loss of efficacy in the periphery.

Q-VALUE

When the effect noted by Hersh is not taken into account, treating existing aberrations may lead to induction of new ones. To avoid inducing aberrations, we must consider one of the cornea’s key characteristics, the index of asphericity (Figure 1). Also known as q-value, this index is fundamentally linked to corneal aberrations, particularly spherical aberration. If the q-value is equal to 0, the curve has no asphericity and is, by definition, a perfect sphere.

The q-value of the normal cornea has been investigated extensively, with wide variation in reported measurements. The ideal q-value for a human cornea has been computed to be -0.26. Figure 2 illustrates the induction of spherical aberration through laser vision correction. It has been found that radical changes to the q-value detract from image quality, and therefore the goal of refractive surgery should be to maintain the natural q-value rather than to attain a target value.

Recently, Chan et al reported a significant reduction of induced spherical aberration in refractive surgery when the postoperative q-value was designed to be as similar to the preoperative value as possible, compared with a control group. Treatments such as this may now be used to enhance vision and maintain the natural asphericity of the cornea.

STUDY

The multicenter study reported below involved 802 consecutive myopia treatments on 494 patients (mean age, 35.1 ± 9.2 years). The target refraction was plano for distance vision. Fourteen surgeons at 25 centers used their own individual nomogram adjustments; 106 eyes (13.2%) were treated with LASEK flap creation and 694 (86.8%) with all-laser LASIK using the IntraLase FS 60 (Abbott Medical Optics Inc., Santa Ana, California) to create the flap. All eyes underwent laser vision correction with personalized aspheric treatment (Zyoptix 217 ± 100 laser). Mean preoperative sphere was -3.39 ± 2.14 (range, -0.25 to -10.25) and mean preoperative cylinder was -0.85 ± 0.82 (range, -0.25 to -5.50). At 1 month, six eyes (0.7%) lost 2 or more lines of distance BCVA; however, by 3 months, no eye was reported as having lost 2 or
more lines (Figure 3; Table 1). Only two eyes (0.2%) underwent retreatment by 6 months.

**DISCUSSION**

These results reflect a high degree of accuracy, which we attribute to the refined treatment algorithm. This algorithm addresses the full extent of the preoperative aberration in such a way that no other aberrations are induced. Thus, results as early as 1 month show high performance in terms of UCVA and residual postoperative refractive error. What is most striking about these results is that there is little difference between highly ametropic and astigmatic eyes and those with low preoperative error. One reason for this may be that the personalized aspheric treatment involves an aggregation of developments, not only in the treatment algorithm but also in eye tracking. The Zyoptix platform features real-time correction of cyclotorsion governed by true iris recognition, which, according to Technolas, allows individual recognition of any eye.

Across the range of prescriptions surgeons treat today, we now have more mastery over aberration and the ability to optimize and customize postoperative quality of vision. Surgeons can target a specific corneal curvature, one that is closely related to the patient’s preoperative curvature but also augmented by eliminating preoperative aberrations. Surgeons can now offer patients a personalized treatment that avoids inducing aberration as a function of the treatment.

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