

# Cataract & Refractive Surgery TODAY

**EUROPE**

## Refractive Surgery at the Cutting Edge

Maximizing outcomes with the latest-generation excimer laser systems.



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# Wavefront Customization Strategies

There is no one-size-fits all solution.

BY JERRY TAN, FRCS(ED), FRCOPHTH



Aberrations are alterations of the optical surface that lead to deviations in the way light enters the eye. Such changes can trigger a decline in visual quality and a loss of contrast sensitivity. The root cause of aberrations is mainly due to abnormalities in two structures, the cornea and the lens, but changes in other optical structures such as vitreous condensation or uneven tear film can also contribute to the development of aberrations.

There are several points that must be considered when discussing aberrations. First, aberrations can either be of the lower order, which include spherical (myopia and hyperopia) and astigmatic defects, or of the higher order, which include spherical aberration, trefoil, and coma aberrations. Higher-order aberrations (HOAs) have the greatest impact on surgical results. Second, aberrations change with age. It is natural for spherical aberration to remain positive on the cornea, but spherical aberration on the crystalline lens is negative. As the crystalline lens ages, spherical aberration will change, thereby resulting in positive spherical aberration. In essence, a young eye is able to compensate for spherical aberration so that total spherical aberration (on the cornea and on the crystalline lens) is approximately zero; however, the total spherical aberration will increase with age due to the changes in spherical aberration on the crystalline lens. The third point is that conventional excimer laser treatments for the correction of ametropia induce corneal aberrations and therefore may cause poor visual quality and loss of contrast sensitivity.

## PRESERVING PREOPERATIVE HOAs

Refractive surgery has evolved from simple myopic ablations to the most sophisticated topography- and wavefront-guided ablations. Such custom ablations are created with wavefront measurements of the whole eye (Hartmann-Shack) or corneal topography-derived wavefront analysis. In order to avoid the induction of aberrations during corneal ablation, special patterns have been designed to preserve the preoperative level of HOAs (Figure 1). This and other recent advances in excimer laser technology, such as the use of aspheric ablation profiles, incorporation of HOA treatments, compensation for induced HOAs, and the use of high-speed eye trackers, have presumably led to better refractive outcomes and

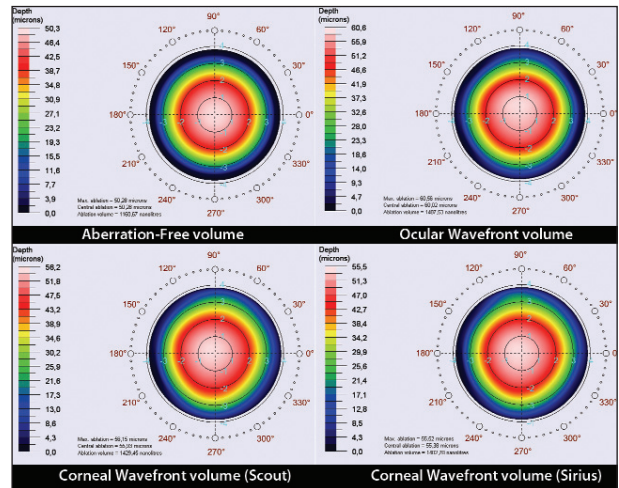


Figure 1. Comparison of ablation volumes of aberration-free, ocular wavefront (irx3), corneal wavefront (Scout), and corneal wavefront (Sirius) profiles in the same patient (-2.50 D with 7-mm optical zone).

reduced HOAs postoperatively.

However, ocular wavefront-guided and conventional LASIK treatments can still increase HOAs by 100% after surgery. A significant number of refractive surgery patients may not even benefit from ocular wavefront-guided treatment, as the induction of HOAs relates to baseline levels. Surgically induced HOAs tend to occur in patients with less than 0.30  $\mu\text{m}$  of existing HOAs but are reduced in patients with greater than 0.30  $\mu\text{m}$  of existing HOAs. In the future with improving technology, I believe that this (arbitrary) 0.30  $\mu\text{m}$  level of existing HOAs will not be the guiding factor to treat patients with HOAs. Even today, it is safe to say that no one-size-fits-all concept can be applied to every refractive surgery patient.

## CORRECTING HOAs

There are three approaches to correct HOAs: (1) objectively eliminate or reduce the eye's total aberrations, (2) correct the corneal aberrations, and (3) avoid inducing aberrations during ablation. We know that the corneal aberrations do not change with age; however we also know that corneal and internal aberrations interact to produce an aberration pattern of the total eye that is different from the aberration

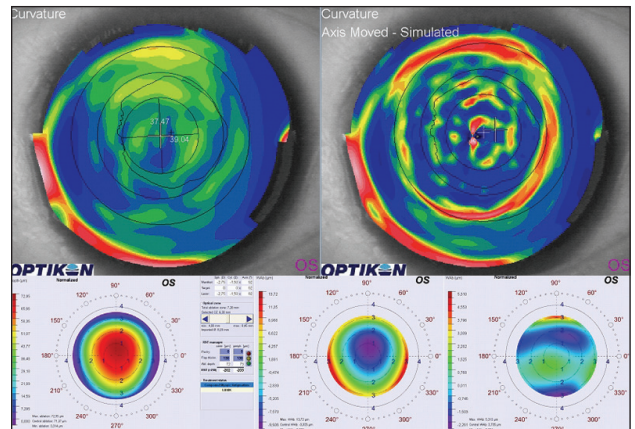
pattern of the cornea alone. For this reason, the first and second approaches to HOA correction should not be applied indiscriminately to everyone. Both can be useful approaches, but they require prior screening of corneal and internal aberrations (in a nonaccommodative state) to know identify which aberrations are balanced and which ones are not. Before either of these treatments is applied, it is also mandatory to signify if the particular type of aberration should be removed or left as is. A point to note if there is significant internal/lenticular HOAs: Consider lens surgery or else avoid laser refractive surgery until the lens needs to be removed. Applying the compensation for lenticular aberrations on the cornea can lead to a poorer resultant vision.

The third approach, which is the aberration-free ablation profile of the SCHWIND AMARIS laser systems (SCHWIND eye-tech-solutions, Kleinostheim, Germany), aims to avoid the induction of aberrations during the excimer laser treatment. The intended result is to keep the eye's HOAs as they were before the treatment while improving visual quality. This type of treatment is not as ambitious; it is a simple approach that can be applied to all patients. The profile's main effects on postoperative coma and spherical aberration occur due to decentration and edge effects, the strong local curvature change from optical zone to transition zone, and the changes from the transition zone to the untreated cornea. When using an aberration-free ablation profile, it is necessary to emphasize the use of huge optical zones that cover the scotopic pupil size and well-defined smooth transition zones. The profile must also include some tolerance for possible decentrations.

## MAINTAIN PREOPERATIVE PROFILE

Based on the random nature of HOA induction and current research in this area, it maybe beneficial to maintain the preoperative wavefront profile for a significant number of refractive surgery candidates. I am not postulating that customized ablation algorithms are not useful; rather, I am saying that only specific populations with specific demands deserve customized treatment solutions. For example, aspheric treatments that aim to preserve preoperative HOAs are beneficial in patients with preoperative BCVA of 20/20 or better or in patients whose visual degradation cannot be attributed to the presence of clinically relevant HOAs.

As part of the corneal wavefront analysis, the type and size of any optical error on the anterior corneal surface is registered, thus allowing selective HOA correction. The defects are corrected exactly at their origin—the anterior corneal surface. In this context, the precise localization of defects is crucial to successfully achieving optimal results in laser surgery. The unique corneal wavefront profile developed by SCHWIND eye-tech-solutions (Figure 2) allows precise diagnosis, thus providing an individual corneal ablation pattern to obtain optimal results. The treatment zone is not limited by pupil size, and accommodation does not influence the measuring results.



**Figure 2.** Concept of corneal wavefront-guided correction. Top left: Preoperative corneal topography. Top right: postoperative corneal topography. Bottom left: ablation map. Bottom center: corneal wavefront aberration. Bottom right: Higher-order corneal aberrations.

This corneal wavefront approach is especially useful in cases with asymmetrical corneas and all corneas previously treated with refractive surgery from radial keratotomy, PRK, and LASIK. Apart from minimal additional ablation of corneal tissue, a systematic corneal wavefront-customized ablation profile is safe and beneficial. The corneal wavefront also is useful when the patient is pseudophakic as many aberrometers have difficulty in achieving an accurate wavefront measurement in the presence of a less-than-perfect posterior capsule. Finally, the corneal wavefront will affect the optics of a cataract patient after IOL insertion.

In Singapore, a coma corneal aberration with mild inferior corneal bulging is often observed. Therefore, the vast majority of my patients are treated using a corneal wavefront-based ablation with excellent results in reducing coma and providing large prolate corneal areas postoperatively.

## CONCLUSION

Ocular wavefront treatments have the advantage of being based on objective refraction of the complete human eye system whereas corneal wavefront treatments have the advantage of independence from accommodation effects or light/pupil conditions as well as in treating previously refractive surgery treated corneas. Aspheric treatments have the advantage of saving tissue, time, and—due to their simplicity— they offer better predictability. When evaluating the outcomes of wavefront-customization strategies, wavefront aberration analysis (both total and corneal) is mandatory to determine whether the customization aims can be achieved. ■

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