The use of wavefront aberrometry is still in its infancy; some surgeons rely on these measurements regularly to produce custom refractive corrections, and others have never performed a wavefront-guided treatment. We know that wavefront analyses can uncover useful information regarding the quality of vision when performed in normal and aged eyes as well as those with various pathologic conditions. However, does using this information during refractive correction translate into optimal outcomes? I would argue that wavefront-guided treatment is the most powerful clinical application of aberrometry, followed by aberrometry’s ability to diagnose irregular astigmatism and to assess optical quality.

BACKGROUND

Aberrometry uses wavefront sensing to measure the complete refractive status of the eye, including imperfections in the optical system such as defocus, regular astigmatism, and higher-order aberrations (HOAs). A wavefront aberration is the deviation of a wavefront that originates from a measured optical system in comparison with a reference wavefront from an ideal optical system. Measuring these aberrations in an eye allows the surgeon to evaluate its optical quality. In some cases, this information can be used to plan a refractive treatment.

The wavefront era began in 1999 with the development of wavefront-guided treatments.1 Using aberrometry, a customized ablation pattern is produced to correct spherical and cylindrical refractive errors and HOAs. These customized patterns can also reduce surgically induced astigmatism. Seiler1 and McDonald2 were among the first to perform wavefront-guided LASIK. From these and other reports, it has been concluded that wavefront-guided LASIK is safe and effective for primary myopia or myopic astigmatism; its use enhances refractive accuracy and postoperative UCVA compared with conventional LASIK treatments.

HOAs are not completely eliminated, however. For this reason, other factors must be introduced to improve the results we have seen thus far in the era of wavefront-guided treatments, including errors of wavefront registration between measurement and treatment, unpredictable changes of corneal shape due to wound healing and/or biomechanics, fluctuation of HOAs, and fluctuation of the beam profile. To date, the acceptance of wavefront-guided treatments may have been stunted compared with its potential applications in refractive surgery.

UNDERSTAND THE CHARACTERISTICS

Surgeons must understand the characteristics of the wavefront measurements they are taking. Because the HOAs of the eye can be expressed as total root mean square error, we can determine a set of coefficients for

TAKE-HOME MESSAGE

- A wavefront aberration is the deviation of a wavefront that originates from a measured optical system in comparison with a reference wavefront from an ideal optical system.
- Customized ablations correct irregular astigmatism, refractive errors, and HOAs as well as reduce surgically induced astigmatism.
- The combination of corneal topography and wavefront aberrometry helps to determine where the astigmatism originates.

Many potential uses lie beyond customized refractive correction.

BY NAOYUKI MAEDA, MD

COVER STORY
sensitivity. Additionally, research has shown that the lens is consistent with the age-related decrease of contrast degree of HOAs in a normal eye correlates with age and corneal inferior steepening. These eyes tend to have higher-order wavefront aberrations as it does in younger eyes.

**Keratoconus.** An increase in vertical coma due to corneal inferior steepening. These eyes tend to have a reverse coma pattern, in which vertical coma is prominent. Other findings with aberrometry in keratoconus include heightened levels of trefoil, tetrafoil, a reverse coma pattern, in which vertical coma is prominent, and secondary astigmatism. HOAs can be used to detect keratoconus and to grade the severity of keratoconus.

**PMD.** Like keratoconus, PMD is categorized as a non-inflammatory corneal thinning disorder; however, it has a unique HOA pattern. The mean axes of coma are the reverse of those in normal eyes, as with keratoconus, but their magnitude is weaker, and the mean axis of trefoil is the opposite of keratoconus. In eyes with PMD, wavefront aberrometry shows a gradual increase in coma-like aberrations and a stable increase in spherical aberrations.

**Refractive surgery.** In multiple studies using wavefront aberrometry, refractive surgery increased total HOAs in small and large pupils, with the most noticeable increase occurring in large pupils. Another finding was that refractive surgery tends to shift the type of aberration from coma to spherical aberration; this shift correlates with the amount of refractive correction. Because there is a strong correlation between visual symptoms and ocular aberrations as confirmed with aberrometry, we can use aberrometry to determine the cause of LASIK-induced aberrations.

**CONCLUSION**

Wavefront aberrometry has multiple applications in the clinical ophthalmic setting, but in most cases it is used for planning wavefront-guided refractive surgery. Although there is room for improvement in the wavefront sensors available today, wavefront-guided treatments produce reliable results. In the future, it is our hope that wavefront aberrometry will also be able to perform serial measurements and to measure aberrations in eyes with severe astigmatism.

In the meantime, this technology has already contributed to our ability to diagnose and treat many ocular diseases, including refractive errors.