

Summary

The ability to measure the wavefront aberration in the human eye more than a decade ago by Liang and associates. At the University of Heidelberg, Germany, inaugurated a new and revolutionary era in refractive surgery. Ocular wavefront aberrations were subsequently thoroughly studied and linked to contrast sensitivity and visual symptoms.

Laser corneal photoablation profiles were soon to correct ocular wavefront aberrations in addition to the spherocylindrical refractive error. Early results published by Sieler and associates by the turn of the new millennium were encouraging. Custom laser-assisted in situ keratomileusis (LASIK) has since been performed worldwide, including the United States after receiving the Food and Drug Administration (FDA) approval, initially for myopia and myopic astigmatism in 2002.

Since then, many technologic improvements have been made to various custom laser platforms, and many studies have been published investigating the efficacy, predictability and safety of wavefront-guided LASIK, with emphasis on quality of vision.

Wavefront-guided ablation and the prospect of “supernormal vision”

On June 12, 1999, the first customized corneal by Theo Seiler, MD, using a Tscherning wavefront measuring system and a 1mm spot laser. Two days after the procedure, the patient’s visual acuity improved from 20/12 best corrected to 20/10 uncorrected. All current refractive lasers induce significant higher order aberrations during conventional treatments.

Most surgeons base their LASIK treatments on the patient refraction taking into consideration the corneal topography or Orbascan data. Although corneal topography provides information about the anterior surface of the cornea and the Orbascan provides additional information about the posterior corneal surface and

corneal thickness, the wavefront technique allow the optical system of the entire eye to be measured.

Wavefront technology can identify the higher order aberrations that are created by current LASIK procedures. Excellent or supernormal vision and enhanced quality of vision may be achieved by eliminating the preexisting and induced higher order aberrations.

Eyes treated with custom ablation have demonstrated less spherical aberration, which is believed to be responsible for most of night vision difficulties.

Wavefront technology involves advanced eye measurement systems that use technology originally developed by astrophysicists, including multiple methods of aberration measurements (Hartmann-Shack, Tcherning, and Ray tracing).

All these devices measure the wavefront distortions that are created by all structures of the eye.

When a ray of light enters the eye, whatever is between the origin of light and the retina (tear film, cornea, aqueous, lens, and vitreous) produces distortions.

Wavefront technology can detect these higher order aberrations (beyond the spherical and cylindrical error) and calculate how the corneal surface should be modified to create a focused image on the retina.

The Hartmann-Shack aberrometry send a flat wavefront into the eye, then passes through and become distorted by the optical media of the ametropic eye, after emerging from the eye the wavefront is analyzed by a sensor. Alternatively Ray tracing technology samples the wavefront one point at a time rather than sampling the whole image at once.

Irregularities in the visual system deform the emerging wavefront and can be analyzed and used as a wavefront based custom LASIK.

The wavefront profile is then converted into an ablation pattern by a complex mathematical inversion of the three dimensional profile.

This profile is used then to determine the amount of tissue that should be removed to correct the lower and higher order aberrations. The wavefront ablation information is transferred to the laser's computer which then calculates the laser shot pattern.

This technology can be applied not only to virgin eyes but also to those who have undergone previous refractive surgery that was complicated by decentered ablation or irregular astigmatism.

One of the real benefits of this technology is to maintain the natural corneal prolate shape after surgery, that contour helps to focus peripheral light rays on the center of the retina, while current myopic corrections cause the central cornea to flatten creating oblate contour which is responsible for functional visual changes, such as reduced contrast sensitivity after conventional LASIK.