

Wavefront-optimised and wavefront-guided LASIK

Recent advances in diagnostic and treatment technologies have led to a major improvement in the quality of vision that can be achieved with LASIK surgery. In the past, patients had their refraction measured by the standard procedure, as used by any optometrist wishing to make a spectacle or contact lens correction. This refractive data was then programmed into the laser for LASIK surgery to be carried out. Now, a new device called a wavefront aberrometer can be used to measure a much more sophisticated description of the optical state of the eye, and this data can be utilised by the new generation of excimer lasers to define a customised treatment. Such treatment aims to specifically correct not only the simple spectacle prescription, but also the higher order optical aberrations present in any individual eye.

Measurement of aberrations

The Tscherning aberrometer shines a fine bundle of red laser beams into the eye, and these form a pattern on the retina at the back of the eye. As the beams traverse through the eye's optical system, they are bent or distorted by the optical aberrations present in the lens and cornea. An image of the laser grid pattern on the retina is captured by a highly sensitive video camera, and then analysed. The optical aberration present in an eye can be broken down mathematically into different components – the Zernicke polynomials. For the average patient having LASIK surgery, the major component of the optical defect is the lower-order aberrations – the spherical and astigmatic components, as are conventionally defined in the spectacle prescription. The extent to which there may be higher-order aberrations in an eye varies from person to person, but they are generally only a small percentage of the overall optical defect.

Wavefront-optimised LASIK treatment

With earlier generations of laser it was possible to correct the spherical and cylindrical (astigmatic) components of the eye's refractive error, but in most instances the higher-order aberrations present in the eye were actually increased substantially by the treatment. The current generation of lasers, such as the Wavelight Allegretto, have been devised to create a treatment profile that does not increase the aberrations in the same way, but leaves the corneal profile in a more natural prolate shape. The enhanced precision and accuracy of this laser treatment programme has the added benefit that it removes about 20% less corneal tissue thickness compared to the previous generations of laser. This treatment profile achieved by the Allegretto laser is called wavefront-optimised. It avoids the creation of higher order aberrations, and achieves a better quality of optical correction. This is especially beneficial for maintaining the visual function in low-light conditions, which was often a problem with earlier laser treatments. Wavefront-optimised LASIK now delivers consistently better visual results than previous laser treatments.

Pre-operative examination

A range of tests and measurements need to be made to determine a patient's suitability for LASIK treatment, and to plan an optimal treatment profile. Wavefront aberrometry is carried out in low light conditions to measure the optical state of the eye when the pupil is dilated. Generally, eye drops are used to achieve a satisfactory level of pupil dilatation. The extent that the pupil dilates in low light conditions needs to be measured, as this is used in deciding the area of cornea over which any laser treatment may be carried out. Measurement of the corneal shape by topography must also be done. The results of all the tests can then be used by the surgeon in planning the treatment.

Wavefront-guided LASIK treatment

From the aberrometry measurements it is possible to generate a unique treatment profile for an individual eye, and such a treatment is termed wavefront-guided. For patients who have only small degrees of higher-order aberrations, a customised wavefront-guided treatment will differ little from the standard wavefront-optimised treatment on the Allegretto. For those with greater aberrations, the benefits of customisation, and the use of a wavefront-guided treatment, are that every small nuance of the eye's optical system is being treated with the aim of enhancing the quality of the optical outcome.

For some patients, a wavefront-guided treatment may not be appropriate. In the forty plus age group, aberrations found in the eye are often due to progressive changes in the optical properties of the lens, and as such it may not be appropriate to try and compensate for them. Equally for patients with very high spectacle prescriptions, the proportion of the overall optical defect accounted for by higher-order aberration may be so small as to make their attempted correction of little value.

If there is extensive irregularity of the cornea, customised treatments can alternatively be based on the corneal topography data rather than the wavefront measurement.

Outcomes

Information from wavefront aberrometry measurements has been used to improve the standard LASIK treatment profile so that the standard wavefront-optimised treatment will generally give little in the way of induced aberration. Wavefront-guided customised treatments are tailor made to correct the pre-existing aberrations found in some patients. A customised treatment goes beyond conventional methods of optical correction, and can potentially improve the optical performance of the eye beyond that which can be achieved with a spectacle or contact lens correction.

In most people the full resolving power of the retina is not utilised because the optical performance of the rest of the eye does not deliver a sufficiently clear image. If the optics of the eye are enhanced, the standard of vision attained can potentially be improved.

The outcome of LASIK treatment is dependent not only on the laser ablation profile, but on many other factors such as the corneal flap, and the biomechanical and biological response of the eye to the treatment. As a result of treatment it is very rare for the quality of vision to be impaired, although this does occasionally happen. In contrast by far the majority of patients will have maintained their level of best corrected vision, and in some the visual quality will actually be better following LASIK treatment.