

# Ray tracing advocated for customised ablations

**Dermot McGrath  
in Lisbon**

ARE wavefront data absolutely necessary to perform accurate, predictable and safe customised ablation procedures? German vision researcher Paul-Rolf Preussner MD thinks not, arguing that a new approach using ray-tracing of the whole eye may deliver equivalent or better refractive results while removing less tissue than wavefront-driven ablations.

Dr Preussner, University Clinic Mainz, Germany, accepted that many clinicians might be reluctant to dispense with wavefront technology, which has become a widely accepted diagnostic tool for customised laser ablation procedures.

"The starting point for my research is the fact that wavefront sensing has limitations when it comes to mapping the aberrations of the human eye. These limitations are defined by the laws of physics. Researchers who measure aberrations as fractions of micrometers are not measuring the actual optical path length differences inside the eye which are in the order of 10-100 micrometers but only Zernike coefficients. The approach is fine for optical systems such as telescopes, but it cannot suffice when applied to the human eye," he told the XXIII Congress of the ESCRS.

## **Aberrometry unreliable**

Dr Preussner pointed out that there are well-founded reasons to doubt the repeatability and accuracy of wavefront sensors when applied to a physiologically dynamic optical system such as the human eye.

"The problem with wavefront is that the results are also highly dependent on factors such as tear film, pupil size, on misalignment between pupil centre and the reflex of the cornea, and so on, so the data

currently available with wavefront aberrometers are not really reliable," he said.

The same difficulties also extend to highly aberrant or abnormal eyes or eyes that have undergone refractive surgery. It also applies to the treatment of monochromatic aberrations only (whereas the eye perceives the

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world polychromatically), changes in ocular aberrations with ageing, and unpredictable biomechanical changes induced by the ablation, by wound healing, and in lamellar surgery, by the flap.

Dr Preussner's alternative approach is to use numerical ray tracing of the entire eye, taking account of data drawn from corneal topography.

He explained that ray tracing works by looking at one point in the entrance pupil at a time rather than measuring the entire entrance pupil at once. The location of where each light ray strikes the retina is detected by photo-detectors that provide raw data measuring the error distance from the ideal conjugate focus point. This data gives direct measurement of refractive error for that point in the entrance pupil and, multiplied for several other points, allows a visual representation of aberrations in the optical system to be built up.

## **Customised ray tracing-guided ablations**

There is also the possibility to customise the software according to surgeon preferences, said Dr Preussner.

"The target corneal asphericity can be either optimised to

achieve zero spherical aberration or can be given an arbitrary value. Preferably the preoperative value is maintained. The accuracy of the approximation of the theoretical ablation profile by the series of single spots of the flying-spot laser is simulated according to the parameters of the laser machine," he said.

Dr Preussner said that the ray tracing approach using topographic data is inherently flexible, as it does not rely on theoretical eye models on which to base its calculations.

"In the case of a pseudophakic eye, I have all the vital parameters that I need so there is no need to make additional model assumptions. In the phakic eye, however, it is of course necessary to make model assumptions about the crystalline lens," he said.

Another advantage of the technique is the fact that it can calculate angular deviations of the optical system in all directions.

"In effect, this means that we are not limited to well-centred eyes with spherical surfaces but can work with decentred eyes, aspheric surfaces, multifocal surfaces or irregular surfaces of the cornea," he said.

Dr Preussner said that the method is designed to provide a one-step approach to correct defocus, astigmatism and spherical aberration with minimum tissue ablation while maximizing the point spread function for better quality of vision. He added that although

the methodology has not yet been tested in a clinical setting, it should prove valuable for preoperative simulations and should be available in the near future as part of the Schwind laser platform.

"A ray-tracing approach taking into account refractions, such as angular optical errors, seems to be more adequate to the human eye than a wavefront approach based on optical path-length errors. It is more suitable also for odd eyes, is more accurate and needs less tissue material ablation," he concluded.

In a brief question-and-answer session following Dr Preussner's presentation, Prof Raymond Applegate expressed reservations about performing customised treatments without using wavefront data.

"I don't believe that you can achieve the same level of results without considering more carefully the optical properties of the whole eye. I am not disagreeing that if you have all the parameters inside the eye, and you know the relevant corneal data and you know what you want to change, that you can do that with good results. I simply believe that wavefront provides much better information on that than other approaches," said Dr Applegate.

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