Is the future of refractive surgery based on corneal topography or wavefront?

A battle may be brewing between the abilities of wavefront and corneal topography. Surgeons will have to decide.

by Michael J. Walsh
Staff Writer

Corneal topography has become the backbone of refractive surgery over the past decade as manufacturers have worked harder to refine the accuracy of their corneal topography systems. Starting with the single, then multi- and then colorized Placido disk systems all the way up to new wavefront technology, a map of the eye is perhaps the single most important information a surgeon needs.

Regardless of what system is used, a corneal map is simply 4,000 to 8,000 distinct measurements of the eye that are combined together to create a simulation, generally in one of four distinctive two-dimensional maps.

The most basic form of corneal topography is the Placido disk, which uses a series of rings reflected onto the eye to measure the corneal surface. From the disturbance produced by imperfections on the eye, a degree of astigmatic error can be computed. In combination with the scanning slit to measure height and the Placido disk to measure curve, a relatively accurate view of the cornea can be extrapolated.

The guts of the topographer

"Both technologies [Placido disk topography and scanning slit] have their uses and are needed," said **Noel A. Alpins, MD, FACS.** He explained that the scanning beam examines the steep and flat surfaces of the eye well, while the Placido principally looks for the astigmatism power and orientation.

Of course for most doctors, the how is not as important as the what when it comes to topographers – what is the problem with this eye? For that, the maps are the most important element to a physician. Some topographers offer a series of four maps: axial, refractive, elevation and irregularity.

The axial map basically takes the readings as light passes through the cornea and how the corneal reflections appear as it happens. "The device can create a refractive power map that relates the corneal shape to what we know as a Snell's law map," Dr. Alpins said.

He explained that the axial map is the most sensitive of the four maps that are created using a corneal topography system. The axial map gives the overall curvature of the cornea, as does the refractive map.

The refractive and axial maps, which Dr. Alpins chalks up to be the qualitative maps used most frequently, answer the question of how good the eye is in a basic functional sense. The other two maps are more quantitative in the sense that they measure the difficulty that the eye may pose in treatment when corneal irregularity is identified before or after surgery.

The elevation map compares the cornea with a sphere and shows where the cornea lies below and above the sphere in measurements of microns. "It gives you the idea of how much thickness of tissue you must ablate for local area ablations," Dr. Alpins said.

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The irregularity map looks to see the irregularities on the cornea, such as various forms of uneven astigmatism, when compared with a best-fit toroid and overall curvature. "It shows the amount and site of local irregularity and provides information when considering how to deal with it," Dr. Alpins said.

One of the main problems for the topography systems when examining idiopathic irregular astigmatism, according to Dr. Alpins, is proprietary algorithms. He explained that each topography manufacturer attempts to promote their topographer as the best for this purpose. However, since each topographer uses a different set of algorithms to create an index of some sort from the measurements taken off the eye, making a true comparison between corneas examined on various topographer models difficult.

"And I believe one of the biggest complaints that physicians have is the lack of standardization. You have a topographer and someone else down the road has a different topographer and you can't easily make a direct comparison between the two sets of values," Dr. Alpins said.

He pointed out that this was particularly the case during symposia and meetings when doctors use screen shots from the topographer to demonstrate a problem, but because the topographers all use different mathematical models to come to a quantitative conclusion, readings may appear more different than they would otherwise be.

Looking at the future of corneal topography and how the industry and the response of the doctors will change in the new century. Dr. Alpins said, "Most doctors who are doing refractive surgery have probably already bought their topographer and they're not really looking to buy a new one in the short term. Because of that, the market is a little bit saturated and, as a consequence, the companies have been dropping their prices, reducing their capacity for R&D. On top of that, they're being hit with this new technology called wavefront analysis. It's the thing of the moment and so topographers have become, for a temporary period of time, of secondary importance."

Wavefront's abilities

In terms of wavefront technology, Dr. Alpins expressed the same concerns that several other physicians have had in the past months about the true potential of the technology.

In the most basic sense, wavefront technology shines several light beams into the eye and then reads their reflections as they return and pass back through the cornea. Whatever deviations occur in the micro pencils of light will be highlighted by the algorithms of the wavefront technology and their exit separation measured for refractive error.

"It's essentially a ray tracing of 64, or 128, or 200 rays of light passing through the optical system of the eye, each taking its own path and providing a map of the refraction just as corneal topography provides a detailed map of the keratometry," Dr. Alpins said. "So the wavefront technology is providing us with some better numbers on the refraction because it has multiple values, but it's still a refractive-based diagnostic number and not a solution for treatment."

The bonus of wavefront technology is that virtually every aberration within the eye's transparent media can be measured very accurately. Therefore, higher-order aberrations and those spherical aberrations on the cornea can theoretically be rectified, making for an even more perfect visual acuity with a more prolate shape.

"It's useful in being able to model excimer surgery to better contour the cornea. However, if you attempt to neutralize all the internal aberrations on the corneal surface, you can create more of an irregularity, or a cobblestone cornea," Dr. Alpins said.

He also said it was possible that as the cornea healed, the epithelial healing process itself might reverse those altered higher-order aberrations. Those changes, as well as the pinpoint changes the laser made, could make for a potentially uneven cornea. "This is the true challenge that wavefront faces," Dr. Alpins said.

For instance, the computer modeling studies Visx (Santa Clara, Calif.) has done suggest that wavefront "polishing" may not create a standard Munnerlyn shape, but rather an irregular-shaped cornea.

"As of right now, we need to better understand higher-order aberrations before we start correcting them," said Visx Vice President of Research and Development **Carol F. H. Harner, PhD.**

She explained that the wavefront provides so much information, it is important to test exactly what the laser can do and how much of a difference adjusting those aberrations might make on visual acuity.

Dr. Alpins warned against more than just the "cobblestoning" of the cornea, but also on the perception that once wavefront technology is made widely available, doctors can simply put their topographers in the basement.

"It's being suggested that topography is not as useful as we thought it was [with the advent of wavefront]. But I completely disagree with that. Wavefront analysis is fundamentally a refractive value. I believe topography is possibly even more useful because it's the only way we can gauge how good or bad treatment employing wavefront analysis is doing," Dr. Alpins said.

"Those who promote wavefront refraction as the sole treatment mode to achieve what they call 'super vision' seem to miss the point that to improve the visual potential of an eye, one must reduce the amount of irregularity of the cornea by addressing the topographic disparity.

"Treating by refractive values alone, such as wavefront, can increase irregularity by attempting to correct the aberrations contained within the media of the eye on the surface of the cornea. This would produce less than optimal or even adverse visual outcomes in a significant proportion of patients," Dr. Alpins said.

"In the end, it has to be a marriage between [topography and wavefront], because you can't just treat with one and disregard the other, which can give the patient an unpleasant refractive or topographic surprise," Dr. Alpins said.

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Dr. Alpins has no direct financial interest in any of the products mentioned in this article, nor is he a paid consultant for any companies mentioned.