Custom ablation - fact or fiction?

Dermot McGrath
in Dubai

WAVEFRONT guided customised ablation represents an exciting addition to the modern refractive practice, but surgeons should resist the temptation to consider it a ‘silver bullet’ solution for the refractive needs of all patients, according to an international panel of vision scientists.

In a symposium devoted to the theme: “Customised ablation: science fiction versus science facts”, held during the VIII International Congress of the Pan Arab African Council of Ophthalmology, the panel sought to clarify the main issues surrounding customised ablation as well as providing some guidelines and tips for clinicians interested in incorporating such technology into their refractive practices.

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Dr Seiler noted that wavefront-guided ablation is based on the wavefront analysis of the whole eye and is the most complete optical approach, providing additional information about the refractive state of the eye and especially the higher order aberrations that frequently result in visual symptoms.

Wavefront technology provides a detailed ‘fingerprint’ of the eye. He noted that this gives a very accurate picture of the refractive state along with higher order aberration information that can be used to learn why an individual patient might be unhappy with a prior refractive surgery and then to plan a treatment to help reduce those aberrations.

He noted, however, that wavefront technology has its own inherent limitations that should be borne in mind when selecting candidates for customised treatments.

“In my experience, wavefront analysis is time-consuming and is not always reliable enough to serve as a basis for treatment. Primarily, it should be used in the dominant eye and in eyes with an RMS-wavefront error of more than 0.3 microns. This technique also should be used in retreatments of small and decentred optical zones when reliable wavefronts can be measured,” said Dr Seiler, who noted that wavefront-guided treatments account for only 10% to 20% of all treatments in his practice.

Turning to topography-guided ablations, Dr Seiler said that this approach offers more therapeutic applications based on the elevation map of the cornea derived from standardised corneal topography.

“This is particularly beneficial for highly aberrated eyes, and applies to all kinds of irregular astigmatism. I also use it in our clinic for retreatments after refractive surgery, astigmatism after penetrating, or lamellar keratoplasty, form fruste keratoconus, and for cases of irregular post-cataract astigmatism,” he said.

Dr Seiler said that the more recent innovation of the Q-factor optimised profile is a promising development that takes account of both preoperative corneal asphericity and the target asphericity after treatment.

“This is an efficient treatment profile that results in superior corneal optics because it takes account of the ideal prolate shape of the cornea. Current results with this technique are extremely promising and we believe that this approach will replace standard profiles,” concluded Dr Seiler.

Better prolate than oblate

The benefits of customised prolate excimer ablations to reduce aberrations in the eye were discussed in greater detail by Jack Holladay MD, USA, who said he was gratified to see that laser companies are finally catching on to the importance of preserving the natural prolate shape of the cornea.

“I have been talking about the need to create prolate corneas for more than eight years now and it is heartening to note that we are finally moving in the right direction in terms of ablation profiles,” he said.

Explaining how laser treatments induce spherical aberrations, Dr Holladay said that the principal reason is that the lasers are calibrated on flat surfaces where energy distribution is always perpendicular to the surface. The cornea, however, is dome shaped and the effective energy drops off as the laser leaves the centre of the treatment resulting in an oblate shape and induced spherical aberrations.

“By changing the ablation profile and applying more laser power to the corneal periphery, every cornea will be prolate and the size of the optical zone will remain the same regardless of the amount of treatment,” he said.

Dr Holladay said that initial treatments using the Optimized Prolate Ablation (OPA), which he had helped to develop in collaboration with Nidek, have proved very promising. The OPA profile allows surgeons to take due account of the natural ageing process of the crystalline lens and to compensate for the positive spherical aberration induced by the hardening of the natural lens over time.

“This is why we need to know the age of the patient in order to give a truly optimised treatment. In fact, with the OPD Scan that measures wavefront and topography in the same machine, we can measure that total ocular spherical aberration in a specific patient and take account of the topography to design a new prolate shape that matches or slightly over-corrects the existing cornea and crystalline lens so the patient will continue to improve for several years,” explained Dr Holladay.

Combining wavefront and topography

Focusing on developments in aberrometry, Stephen Klyce PhD suggested that combining whole eye wavefront measurements and corneal topography data might help to improve the accuracy of custom corneal laser ablations in aberrated eyes.
While most current wavefront sensors are based on either Hartmann-Shack or Tscherning principles, Dr Klyce explained that the Nidek OPD-Scan functions as an autorefractor, wavefront analyser and corneal topographer in the one unit. The OPD-Scan utilises the principle of dynamic skiascopy for aberrometry and provides the highest spatial density of measurements of any wavefront sensor in normal use. The retina is scanned with an infrared light slit beam, and the reflected light is captured by an array of rotating photo detectors over a 360-degree area.

He noted that the OPD-Scan could determine the optics of the whole eye directly in units of dioptries, which makes these data more amenable to clinical interpretation. The built-in corneal topographer provides a more certain means for registration of the cornea with wavefront and topography data when used to guide laser surgery. Another plus is that with data from both the whole eye and the corneal surface, the internal aberrations of the eye can now be calculated to determine the optics of the natural or implanted lens.

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Stephan Klyce MD

Although Zernike polynomial expansion has traditionally been used to visually represent the raw wavefront data obtained from aberrometers, Dr Klyce said that such an approach works best with normal corneas.

“We have evaluated the fidelity of Zernike expansion to model the corneal surface and have found that while normal corneas were well matched, irregular post-surgical and pathologic corneas were poorly matched. Our current studies show that Zernike polynomials are a smoothing function that cannot faithfully represent all the aberrations that degrade vision,” he said.

Dr Klyce said that initial tests involving two-dimensional Fourier analysis indicates that it may ultimately offer a more accurate method of modelling pathologic corneal surfaces.

Quality of vision

Focusing on the differences between standard LASIK treatments and customised ablations, Aleksandar Stojanovic MD, Norway, said that his clinical experience showed that patients treated by custom methods should expect a better quality of vision than those treated by standard methods.

Dr Stojanovic presented one-year results from a prospective, randomised, contralateral, double-masked trial of 120 eyes of 60 patients who were treated for myopic astigmatism using the Lasersight ASTRA system. One eye was treated with custom ablation and the other eye with standard treatment. Biased randomisation was used so that there was an equal amount of dominant eyes in both groups, said Dr Stojanovic.

Preoperative and postoperative best corrected visual acuity, uncorrected visual acuity, predictability, spherical aberration, coma and the other higher order aberrations in the two groups were compared. Topographies were analysed and compared with respect to corneal asphericity and micro decentrations. Results showed that 46% of eyes treated with standard LASIK gained lines of best-corrected visual acuity compared to 50% of custom-treated eyes. There was also a statistically significant difference in efficacy in favour of custom treatments. In subjective questionnaires, 72% of patients could identify their custom treated eye as having a better quality of vision. Eyes treated with the ASTRA system also recorded a better postoperative Q value, as the custom ablation profile is designed to maintain the prolate shape of the cornea compared to the oblate shape induced by standard treatments.

Consequently the induction of spherical aberration was significantly less in “custom eyes”, as it strongly correlated to corneal asphericity change (R2=0.75). The induction of coma was also significantly less in “custom eyes”, and it strongly correlated to the amount of micro decentrations (R2=0.71). Nevertheless, there was not any significant reduction of preoperative higher order aberrations in any of the two groups.

Dr Stojanovic cited three key factors which might account for why custom treatments resulted in better quality of vision, in spite of there being no reduction of preoperative higher order aberrations. First, preserving the cornea’s natural prolate shape by increasing the laser energy delivered to the corneal periphery results in less induction of spherical aberration and better quality of mesopic vision. Secondly, the fact that the optical centre of custom treatments is centred on the optical center of the cornea (which in virgin eyes coincides closely with the intercept of the visual axis), rather than the centre of the pupil, is an important factor in reducing the induction of asymmetric, coma-type higher order aberrations.

And finally, custom treatments require precise registration with respect to cyclotorsion, something that also contributes to lesser amount of induced coma-type higher order aberrations. Dr Stojanovic said that this raises the question of whether the outcomes with standard treatments would provide equally good vision as the customised treatments if they included optimisation for asphericity, centration and cyclotorsion.

We know that higher order aberrations change over time, but if we can predict these changes and plan how to fix these aberrations in the future, that would be a major advance.”

Alaa El-Danasoury MD

In another comparative study, Alaa El-Danasoury MD, Saudi Arabia, found fewer clear-cut differences in terms of refractive outcomes between the performance of standard LASIK and customised treatments, although most patients did express a preference for their custom treated eye.

Patient preference for customised treatments

In a further comparative study, Alaa El-Danasoury MD, Saudi Arabia, found fewer clear-cut differences in terms of refractive outcomes between the performance of standard LASIK and customised treatments, although most patients did express a preference for their custom treated eye.

“Dr El-Danasoury said that this ideal ablation profile is becoming a reality in the form of the Optimized Prolate Ablation (OPA) profile that is currently under investigation. He added that once this ablation profile is available it will help maintain the prolate shape of the cornea, reduce both lower and higher order aberrations and greatly improve the quality of vision of patients for years to come.

ORK-CAM preserves corneal prolate shape

A further indication of the growing importance of prolate-friendly ablation profiles was provided by Maria Clara Tscherning, Denmark, who presented results from a series of 65 eyes treated using ORK-CAM software (Schwind Eye-tech Solutions).

“The amount of induced spherical aberration was significantly reduced in all eyes treated with standard aspheric ORK-CAM profiles, while in those eyes treated with corneal wavefront-guided aspheric profiles the amount of spherical aberration decreased by 85%,” she said.

She said that the approach of
performing laser treatment based on aspheric ORK-CAM ablation profiles combined with the new pulse sorting algorithm leads to a better shaped, smoother cornea with improved vision.

“We experienced no serious complications in this series, just a few cases of undercorrection. The data we have seen to date are very promising for precise and predictable values and also in terms of refraction, asphericity, spherical aberrations and contrast sensitivity,” she said.

Beshr Kenawi MD, Egypt, presented another study assessing the effectiveness of customised laser ablation to treat corneal irregularities, noting that customised ablation aims to deliver a high quality and quantity of visual acuity.

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“Quantity of vision means without glasses or contact lenses, while quality refers to no glare, no haloes, no dry eyes, no shadowing and no diminution in contrast sensitivity,” he explained.

**Biological limitations of ablations**

Dr Kenawi said that while customised ablation delivers excellent results in carefully selected cases, it also has its own inherent limitations.

“I have a lot of doubts about our ability to treat all higher order aberrations because the amount of tissue change needed for such subtle refinement is about 5.0 nanometres, which is about the thickness of a single epithelial cell. So there is a biological limit to keep in mind. Also, the aberrations inside the eye change with factors such as accommodation, pupil size, illumination conditions and ageing plus the negative effect of the LASIK flap. Moreover, the ideal corneal shape is clinically unknown as yet,” he emphasised.

Dr Kenawi noted that the cornea cannot be re-sculpted under the demanding requirements of larger degrees of correction and larger pupils in dim light without the highest quality laser beams being used to remove tissue as precisely as possible. But he still believed that the technology has much to offer today’s demanding patients.

“I think that customised ablation patients have a greater chance of obtaining 6/6 visual acuity, a smaller risk of losing BCVA and night vision and contrast sensitivity and a greater chance of restoring BCVA,” he said.

In a presentation of clinical results obtained using the Q-value adjusted topography-guided ablation profile on the Allegretto Wave Eye-Q laser system, Osama Ibrahim MD, Egypt said that he had been impressed with its performance on eyes with irregular secondary corneal astigmatism after previous refractive surgery.

“The Allegretto Wave Eye-Q system is an effective and safe technique for improving corneal irregular astigmatism resulting from previous refractive procedures,” he said.

Dr Ibrahim’s study included 16 patients with complications such as decentred ablations, residual astigmatism or small optical zones.

He noted that the retreatments greatly improved the postoperative topography and succeeded in enlarging the optical zone in all patients. All eyes achieved a better quality of vision and improved BCVA, he noted.

“Most of the patients gained more than one line and none of them lost any lines. We still had some residual refractive errors in about half of the patients; and in about one third a second intervention was necessary to correct refractive errors whether with a standard treatment or a wavefront guided treatment,” he said.

**Patient selection vital**

Omid Kermani MD, Germany, stressed the importance of careful patient selection in obtaining the best results from customised ablation. He presented a case series of 1,420 eyes treated with the Nidek OPD-Scan and Nidek EC-5000 XTRII laser system. All eyes received aspheric ablations, 152 eyes additionally were treated with OPD-wavefront guided customised segmental ablation.

Dr Kermani said that the treatments were safe, predictable and resulted in a high level of patient satisfaction although there was no statistical difference in terms of the refractive outcome between patients treated with standard or customised treatments. However, more than half of the eyes that received custom ablation gained 2 or more lines of best corrected visual acuity.

“I believe that customised LASIK is very promising in selected cases. About 10% of our cases are treated with customised LASIK since we have to be absolutely sure that each individual patient will benefit from the type of treatment that we are offering. The best preconditions are if the visual acuity is 20/20 or less and the patient has a large pupil and high RMS error. It is clear that customised ablation is moving from challenging fiction to clinical fact,” he said.

Turning to the possible benefits of using a femtosecond laser to create the flap in customised ablation procedures, Karl Stonecipher MD, United States said that the IntraLase laser seemed to offer more predictable flap thickness and Greater patient satisfaction than mechanical microkeratomes.

Dr Stonecipher’s prospective study evaluated the results from two subsets of patients: Group 1, which underwent wavefront optimised treatments using a Moria 130 micron blade disposable keratome; Group 2, which underwent wavefront optimised treatments or wavefront guided treatments with the IntraLase laser keratome. All ablations in this prospective study were performed using the Wavelight Allegretto Wave laser under FDA clinical guidelines.

Dr Stonecipher reported that flap safety for Group 1 revealed loose epithelium in 6.1% whereas Group 2 showed no loose epithelium. Neither group had epithelial defects. Flap predictability for Group 1 showed a range of 86um–197um and for Group 2 showed a range 99um–168um. Uncorrected visual acuity was greater than or equal to 20/20 in all three groups.

Dr Stonecipher said that a retrospective review of 17,362 cases which had undergone laser ablations using a mechanical microkeratome and a VISTX laser indicated an enhancement rate of 4.17%, a statistic that he feels has improved considerably since using IntraLase.

“With the switch to the IntraLase platform on the same VISX laser, I have brought the enhancement rate down to 1.6%. In other words, it makes a big difference and it makes for happier patients,” he said.

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