The Ideal Excimer Laser

Many ideal features are already — or are about to be — implemented into some excimer laser platforms.

BY DAMIEN GATINEL, MD

With its ability to remove corneal tissue with an accuracy up to 0.25 µm with each pulse, the excimer laser is the most precise tool ever invented for vision correction. Its cool or nonthermal light beam makes it ideal for corneal surgery because it eliminates the possibility of thermal damage to surrounding tissue.

Several excimer laser units are available on the market and provide excellent treatment capacities. Here follows a nonexhaustive list of what would make excimer lasers even better. Some of the described features are already or about to be implemented in some laser platforms.

TECHNICAL SPECIFICATIONS

Ophthalmic laser applications require high reliability. Highly stable energy output has to be monitored and controlled with the internal energy detector and stability module. The laser optics should be virtually free of contamination and deliver superior performance with respect to longevity and damage resistance for 193 nm UV wavelengths. Long optics and long static gas lifetime, with increased number of pulses, would make maintenance a lesser constraint and lower the cost of ownership.

Excimer laser products should be of solid construction and favor the use of metal or ceramic over elastomers or plastics. Externally, they should combine ergonomics and design while minimizing the volume that they occupy in the surgical theater.

The optics of the surgical microscope have to provide superior resolution and allow the visualization of subtle details in the ocular segment of the eye, in order to facilitate interface inspection in LASIK procedures. The illumination of the eye has to be sufficient, especially for patients who have dark irises.

The laser calibration maneuvers should be fast and accurate, and ideally, should be automated.

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DATA SELECTION AND PROCESSING

Avoiding treatment data entry errors is crucial. When using a patient's electronic record file, network cable or wireless data transmission from the diagnostic unit server to the laser should be accessible, particularly for customized treatments. This would reduce the need for USB memory sticks, floppy disks and CD-ROMs, which can be lost or corrupted.

If manual, the data selection process in the laser software should be easy and effective to minimize the risk of errors of treatment programming. Displaying the astigmatism treatment axis and/or the pattern of ablation on the computer screen may help to avoid error and increase treatment efficiency by suggesting ideal hinge location with LASIK.

PROFILE OF ABLATION GENERATION

Today, the concept of customization is not restricted to the photoablations based on either wavefront or topography treatment, but embraces all the situations where the conditions of the treatment can be tailored to ocular and patient characteristics. Ideally, the elaboration of the profile of ablation should take into account for the items listed below

Pupil size and dynamics. The best compromise between optical zone size and depth of ablation should be determined for each patient. Ideally, the optical zone width should exceed the dimensions of the scotopic pupil diameter. This may not always be possible, however, in order to control the maximal depth of ablation.

Depth of ablation. Astigmatism correction should always be performed using a strategy that minimizes the depth of ablation. Even if entered in negative cylinder format, the ablation profile should be elaborated from the plus cylinder format for mixed and compound hyperopic astigmatism.

Transition zones. Their role is to allow an adequate blending of the ablated central optical area into the untreated periphery. Transition zones should also help to reduce unwanted glare and halos, while avoiding excessive increase in the central depth of ablation. Avoiding rapid curvature changes and abrupt edges at the periphery of the optical zone may improve functional outcomes and treatment stability. This is particularly important in high magnitude, hyperopic, toric and/or topography- or wavefront-customized treatment strategies. The laser software should generate optimized transition zones that may, however, be adjusted by the surgeon if necessary.

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Combined used of wavefront and topography data. This may help to achieve the aforementioned tasks and provide superior customization ability. For example, it may be decided to leave some aberrations of crystalline lens origin untreated in some patients while deciding to correct the whole eye aberration in others, depending on various factors. The challenge in obtaining the appropriate alignment between the wavefront and the corneal surface should be resolved in the future. Using diagnostic instruments that would allow simultaneous acquisition of the corneal and wavefront data may achieve this.

Implementation of reliable and efficient multifocal profiles. This would be mandatory to address the future refractive corrections in the growing market of presbyopia. The combination of future technologies (eg, adaptive optics and vision simulation) and a better understanding of the mechanisms of corneal response to the excimer laser allow us to envision the acquisition of better results in multifocal ablations.

Nomograms. Some surgeons may want to develop specific nomograms that include successive treatments, or feature added-PTK ablations, etc. This should be possible with combined treatment laser software.

The duration of the treatment should be short but not increase the temperature over the corneal surface.

Expected corneal response. Finally, next generation of profile of ablation implemented in excimer laser units should take into account the expected corneal response in order to counteract the effect of biomechanics and wound healing. Ideally, the laser software could also have the ability to interpret the data extracted from an updated patient's database, in order to suggest even better treatments designs based on the surgeon's previous results.

PROFILE OF ABLATION DELIVERY

Building the most appropriate profile of ablation in a given patient is worthless without the use of additional efficient measures aimed at ensuring its adequate delivery on the treated corneal surface. A rotationally sensitive eye tracker, using fixed ocular landmarks, should be used routinely in this regard. These features should work in combination with precise delivery systems, in order to warrant that not only the eye movements would be tracked, but more importantly, that every laser pulse shot would reach the intended location on the cornea.

Wrongly positioning the patient's head should be prevented using a comfortable headrest and adequate lightening marks to properly align the patient so that the ocular plane would be perpendicular to the treatment axis. Online pachymetry and online topography would be very desirable features, to control the depth and topography of the laser ablation, improving both treatment safety and precision.

The duration of the treatment should be short but not increase the temperature over the corneal surface. This requires either the use of high treatment frequency and/or intelligent repartition for the spot sizes and location. ■

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