Balancing lower and higher order aberrations enables fine-tuning of customised ablation algorithm

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THE tendency for hyperopic overcorrection to occur in wavefront-guided treatment of myopia can be explained in part by an optical interaction between positive spherical aberration and defocus. Taking that information into account to adjust the wavefront-guided ablation algorithm can significantly improve refractive outcome predictability, reported researchers at the annual Association for Research in Vision and Ophthalmology conference.

Investigators used optical modulation transfer function to assess theoretical retinal image quality associated with different levels of spherical aberration. Those studies showed that in the presence of positive spherical aberration, optimised retinal image quality depended on additional defocus. Based on a 6.0mm pupil, each 0.1 micron of positive spherical aberration was found to be associated with an approximate 0.25 D myopic shift in refraction if other higher order aberrations were relatively small.

That information was consistent with results of analyses investigating relationships between pre-operative spherical aberration and six-month postoperative spherical aberration and refraction in the 340 myopic eyes treated in the US FDA clinical trial of Zyoptix customised LASIK (Bausch & Lomb). Those analyses demonstrated that the amount of pre-operative spherical aberration was inversely related to the amount of induced spherical aberration and proportional to the amount of postoperative spherical overcorrection, while a statistically significant relationship was also identified between the amount of induced spherical aberration and the amount of postoperative hyperopia. The investigators have been deciphering these types of “aberration interactions” over the past two years using data from large clinical trials.

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In the FDA clinical trial, the 340 myopic eyes had a mean pre-operative SE of -3.32 ± 1.54 D and mean cylinder of -0.68 ±0.59 D. At six months after surgery, 74 eyes (22%) had a manifest refraction greater than +0.5 D, including 20 eyes with an SE of more than +1.0 D.

Division of the eyes into four groups based on level of pre-operative spherical aberration (<0, 0-0.2, 0.2-0.4, and >0.4 microns) demonstrated the degree of postoperative hyperopia measured in manifest refraction increased with increasing amounts of pre-operative spherical aberration. Mean postoperative refraction was very close to plano in eyes with negative spherical aberration and reached an average of about +0.66 D in the group with the highest level of pre-operative positive spherical aberration (>0.4 microns).

For the entire cohort of eyes, the surgery induced an average of 0.17 microns of positive spherical aberration. Analysis of a relationship with pre-operative spherical aberration showed the amount of induced spherical aberration decreased with increasing amount of positive pre-operative spherical aberration.

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Geunyoung Yoon PhD

However, the smaller amount of induced spherical aberration resulted in an increase in postoperative hyperopia because of the interaction between spherical aberration and defocus,” Dr Yoon said.

New nomogram suggestions

In order to minimise problems with overcorrection, the Rochester nomogram for Zyoptix customised LASIK has been modified based on the identified interactions between spherical aberration and sphere. For patients with up to 0.2 microns of positive spherical aberration, the nomogram was not changed, but for treatments in eyes with larger amounts of spherical aberration, it was adapted to slightly undercorrect the myopia to achieve a postoperative sphere result that is closer to target.

An analysis comparing outcomes of 265 myopic eyes treated with the adjusted nomogram and a cohort of 112 eyes treated at the University of Rochester in the Zyoptix FDA trial demonstrates the compensation for pre-operative spherical aberration improved the efficacy and predictability of the treatment and dramatically reduced the proportion of overcorrections. The 265 eyes had a mean SE of -4.72 D and total RMS for higher order aberrations of 0.53 microns. Mean SE and total RMS values for the control group were -3.41 D and 0.45 microns, respectively.

Based on data collected at a one-month follow-up visit, there were significant differences favouring the group treated with the adjusted nomogram with respect to proportion of eyes achieving UCVA of 20/20 or better, 94% vs. 91.5%, mean SE values, -0.07 D ± 0.26 D, proportion of eyes within 0.5 D of target SE, 93.6% vs. 72.6%, and proportion of overcorrected hyperopic eyes (SE equal to or greater than +0.5 D), 2.3% vs. 26.8%.

Dr MacRae told EuroTimes that the study documents the significant improvements in outcomes that can be obtained by understanding “aberration interactions”.

“I think this is the next frontier in customised ablation in normal individuals, but it is even more important in patients with large amounts of higher order aberrations, such as eyes that are post-penetrating keratoplasty. These aberrations are talking with each other, and we need to understand their dialogue,” he said.

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