by Cheryl Guttman in London

Compensation for pupil centroid shift appears to be of greater importance for optimising visual outcomes of wavefront-guided refractive surgery than adjustment for cyclorotation, according to a study reported at the XXIV congress of the ESCRs.

Dr Koch and colleague Li Wang MD, PhD, from Cullen Eye Institute, Baylor College of Medicine, Houston, Texas, measured the amount of cyclorotation and pupil centroid shift in 58 consecutive eyes of 38 patients at the time they were undergoing iris registration-enabled CustomVue (AMO/Visx) LASIK or PRK with the S4 excimer laser. Then, using proprietary software, they calculated the residual aberrations that would be present if there was no alignment for those movements.

The calculations were based on a 6.0mm pupil and included determinations of the root-mean-square (RMS) for total aberrations (2nd to 6th order), lower order aberrations (2nd order), higher-order aberrations (3rd to 6th order), and normalised polar Zernike coefficients (Z20, 22, 31, 33, 40, 42, 44, 51, 53, 55, 60, 62, 64, and 66). The results of all the analyses showed that, compared with lack of adjustment for cyclorotation, failure to compensate for the pupil centroid shift consistently induced significantly higher RMS values with the exception of the Zernike coefficient term Z22 (second order astigmatism), he reported.

"These findings have important implications for what we do at the time of surgery, and indicate that any steps which can be taken to assure the treatment is placed exactly where it is measured during the wavefront exam may be much more valuable than worrying about ocular rotation," said Dr Koch, who holds the Allen, Mosbacher, and Law Chair in Ophthalmology, Baylor College of Medicine.

Lighting conditions key to success

He added, "For surgeons using the S4 laser, one important measure after IR registration is to avoid any change in the lighting condition after the eye is captured so as to prevent any change in pupil size that would induce an intraoperative pupil centroid shift."

Dr Koch explained that most excimer lasers have tracked horizontal and vertical movements of the pupil to optimise treatment accuracy. The iris registration feature introduced for the AMO/Visx S4 laser was designed to further improve treatment placement precision by performing both cyclotorsional registration and pupil centroid shift compensation.

"When that technology became available to us, we were interested in answering the question of which offers more significant clinical improvement. Although a lot of attention has been placed on the potential value of cyclotorsional accuracy, we theorised that controlling for pupil centroid shift might be even more critical since the consequences of an improperly centred treatment would include induction of coma and other higher order aberrations," Dr Koch said.

The patients who enrolled in the study ranged in age from 19 to 59 years, with a mean of 35 years. Mean SE for the group was -3.23 D with a range of -8.55 and +2.24 D. Mean cylinder was -0.92 D with a range from -4.50 to -0.04 D.

Among the 58 eyes, the mean absolute cyclorotation was 2.5±2.0 degrees. The range was between 0 and 8.7 degrees, and the right eye tended to rotate counterclockwise while the left eye generally turned clockwise.

"Notably, the amount of cyclorotation measured in this study is very consistent with other reports of this phenomenon, and we believe the opposite directions of rotation observed in the right and left eyes is a result of relaxation of the superior oblique muscle," he said.

Analyses of the magnitude of pupil centroid shift showed the mean change along the X and Y-axes was minimal, 0.06 and -0.10mm, respectively. However, the vector magnitude averaged 0.29±0.12mm with a range between 0.06 and 0.50mm. The direction of shift was opposite in the right versus left eyes because the pupil centroid shifts nasally in each eye secondary to pupil constriction when the patient is on the operating room table, Dr Koch explained.

In the analyses of the impact of magnitude of rotational error on residual aberrations, total RMS was noted to increase with increasing amount of rotational error, and that correlation was statistically significant. Second order astigmatism was the largest residual aberration induced by cyclotorsional error, but the amount of residual total higher order aberration error was relatively stable across the entire range of rotation observed in the series.

"These data indicate that the predominant problem associated with rotational errors relates to accurate correction of astigmatism, and they imply that for eyes with high astigmatism, cyclotorsional rotation registration is also important," Dr Koch said.

In contrast, for the analyses of the pupil centroid shift data, there were significant positive correlations between the magnitude of the shift and both the residual total and higher order aberrations. Coma (3rd and 5th order) was the largest residual aberration induced by pupil centroid shift.

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