Night vision disturbances after refractive surgery: haloes are not just for angels

Stephen D Klyce

There has been considerable attention paid to the optical consequences of corneal refractive surgery, particularly those occurring during the night time when the pupil widens and larger areas of the sculpted cornea are included within the visual pathway. It seems a forgone conclusion that pupils larger than the functional optical zone (the area of the corneal surface after laser sculpting that provides quality vision¹) created by the surgery should cause problems for the patient and, in truth, this has occurred with night vision complaints that include starburst effects and haloes. Therefore, it has been the strategy over the course of technique development for laser algorithms to sculpt ever larger corneal areas encompassing the full correction zone (the zone of intended refractive correction) and to incorporate cleverly designed surrounding transition zones to blend in curvature changes in a smoother fashion.¹ Taken together, these changes have reduced or eliminated many of the night vision complaints that were associated with pupil diameter, at least in some recent reports.^{2,3}

In this issue, Villa and associates (*see page 1031*),⁴ have re-examined this problem in successful LASIK patients by using a commercial device to measure a night vision disturbance metric, the "halo disturbance index." They also measured the dark-adapted pupil size and the calculated optical aberrations arising from the corneal surface. In this careful study, the authors demonstrate that the halo disturbance index correlates strongly with specific aberrations: notably, spherical aberration, secondary astigmatism and coma. These aberrations, particularly spherical aberration and coma, are consistently reported in the literature as being the major culprits for the creation of visual disturbances following refractive surgery. However, in the current study, no correlation was found between the halo disturbance index and mesopic pupil diameter. This result is in contrast to the experience of many refractive surgeons, yet is consistent with findings published by some.² This finding is encouraging, since it suggests that laser algorithms are improving to the extent where at least some of the lasers being used can treat

patients with larger pupils without inducing night vision problems.

However, there is a caveat: the measurement of pupil diameter has been in standard use in refractive surgical screening procedures, and this should not be altered by the absence of statistically significant post-operative correlations being reported. Not only have these results been reported for an apparent minority of practices, but also, the absence of a correlation between two variables could mean that other variables confound or mask the effect. Simply, with the best of procedures and patient care, the occasional patient with large pupils will experience night vision complaints that are, rarely, debilitating. Still, the prudent course of action would be to evaluate the physical size of the functional optical zones¹ that can be created with a particular laser system at various amounts of correction and compare these with patient mesopic pupil size along with the maximum expected decentration. If the expected functional optical zone can be expected to overlay the mesopic pupil nearly completely, the chance for inducing night vision difficulties after surgery should be minimal. Note that night vision complaints also occur in a substantial number of unoperated patients, and psychometric documentation of these would be a useful adjunct to the patient evaluation routine.

The principle aim of Villa and colleagues⁴ was to correlate corneal higher order aberrations with the halo phenomenon that occurs after what is currently accepted as successful refractive surgeries. Doing so should provide an objective measure of at least one of the forms of night vision disturbance. No psychometric evaluation was reported to determine any level of disability that the patients may have experienced. Rather, the authors used the Starlight device, which is said to measure the halo effect in patients. The Starlight instrument projects a central beam of light as a means to mimic gazing at a point light source under mesopic conditions. At intervals, near perception threshold peripheral point light sources are illuminated in serial fashion to obtain a visual field-like map of retinal sensitivity. When haloes are present, they will distort the peripheral test beams, so that

these will not be detected. The output is a map of targets seen. For the normal unoperated eye, corrected for refractive error, the Starlight device demarcates nearly all the total projected field; normal eyes do not experience significant haloes. For the refractive surgical eye, the device demarcates the region of the visual field over which the near-threshold stimuli were visualised. The peripheral area not seen by these eyes is added up to calculate the halo disturbance index.

While it is clear that haloes will distort light rays and potentially dim the spot produced on the retina below the detection threshold, it also seems likely that other optical effects would have a similar consequence. Disturbances experienced by refractive surgical patients include glare, haloes, starburst, hazy vision, monocular polyopia, simultaneous vision, and defocus. The underlying causes of these phenomena are generally attributed to corneal surface aberrations left behind after refractive surgery. Every one of these symptoms has the potential to reduce the spot intensity of light projected by the Starlight instrument. Hence, while the measurements are objective and meaningful, it is unlikely that they can be used to uniquely identify haloes as the source of visual distortion. It would seem more appropriate to regard the data from the Starlight instrument as a "light distortion index" rather than a "halo disturbance index."

Haloes are an optical phenomenon of nature and can be observed around the sun and stars as a consequence of light scatter caused by ice crystals or other substances in the atmosphere. In the eye, haloes have two main sources. One troublesome source from the past was the halo seen around bright lights particularly at night with hard, low-oxygen permeable contact lens wear. This produced Sattler's Veil, a diffraction phenomenon caused by epithelial edema.⁵ There is the potential for haloes to be formed after surgery if periodic structures persist within the stroma, such as certain types of scar formation. A second type of halo effect in the eye is caused by refraction phenomena and is assumed to be due to the transition zone surrounding the treated area of the cornea. However, this type of halo is actually attributed to spherical aberration. While it is true that an abrupt transition zone can contribute to spherical aberration, it is the shape of the entire corneal region over the entrance pupil that contributes to spherical aberration. Hence, a very large treatment zone and a small pupil can still lead to haloes when there is significant residual ocular spherical aberration.

Despite these reservations regarding the interpretation of data from the

Starlight instrument, Villa and colleagues have provided means and data with which to examine success in refractive surgery in greater detail. Refraction, Snellen acuity, and contrast acuity are still the foundations for assessing refractive surgery, but to understand the causes of visual complaints remaining after treatment, we must look to the techniques Villa and colleagues have championed in their article.

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REFERENCES

- 1 Tabernero J, Klyce SD, Sarver EJ, *et al.* Functional optical zone of the cornea. *Invest Ophthalmol Vis Sci* 2007;**48**:1053–60.
- 2 Pop M, Payette Y. Risk factors for night vision complaints after LASIK for myopia. *Ophthalmology* 2004;**111**:3–10.
- 3 Klyce SD. Night vision after LASIK: the pupil proclaims innocence. *Ophthalmology* 2004;**111**:1–2.
- 4 Villa C, Gutierrez R, Jimenez JR, *et al.* Night vision disturbances after successful LASIK surgery. *Br J Ophthalmol* 2007;**91**:1031–7.
- 5 Lambert SR, Klyce SD: The origins of Sattler's veil. *Am J Ophthalmol* 1981;**91**:51–6.

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