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Small optical zones with aspheric profiles in laser refractive surgery for myopia: A surgical outcome and patient satisfaction study

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ABSTRACT

Purpose: To assess the outcomes of small optical zone (OZ) ablations used in conjunction with large transition zones (TZ) and a highly aspheric treatment profile.
Methods: Interventional case series of 39 consecutive patients with myopia or myopic astigmatism. Patient data included pre and postoperative refraction and visual acuities, laser treatment settings and pre and postoperative corneal topography as well as questionnaire responses about the use of glasses and the quality of vision postoperatively.
Results: The mean preoperative spherical equivalent was -4.50 ± 2.11 dioptres (D) and the mean OZ and TZ diameters were 4.5 ± 0.5 mm and 8.1 ± 0.4 mm, respectively. The mean patient age was 40.7 ± 10.4 years. Manifest spherical refraction was within ± 0.5 D in 87% of patients (± 1.0 D in 99%) and cylindrical refraction within 0.5 D in 79% (≤ 1.0 D in 95%). The need to wear distance glasses postoperatively was associated with dissatisfaction with the quality of daytime vision ($p = 0.05$) and unhappiness with night vision was associated with symptoms of halos ($p = 0.03$) and starbursts ($p = 0.02$). The proportion of patients reporting symptoms of dysphotopsias included: ghosting 0%; glare 2%; halos 10%; and starbursts 15%. There was a significant difference in the measured mean effective OZ diameter (4.8 ± 0.3 mm) compared to the mean programmed OZ (4.5 ± 0.5 mm, $p = 0.00$).
Conclusions: Small ablation zones, when used in conjunction with a large diameter TZ, do not lead to a greater incidence of unwanted visual phenomena over that reported by many studies with larger OZs.

1. Introduction

Corneal laser refractive surgery is highly successful in correcting low order optical aberrations such as defocus and astigmatism but in the process often induces high order aberrations (HOAs), principally spherical aberration and coma [1]. These have been shown to be associated with subjective complaints of dysphotopic symptoms such as glare, halo, starburst and disturbances in night vision following refractive surgery [2].

The attempted degree of spherical correction [1,3] age [4], optical zone (OZ) size [5], pupil size [2] and postoperative spherical equivalent [4] have all been implicated as risk factors for the development of HOAs.

When planning surgery the surgeon needs to balance the potential for inducing dysphotopsias and night vision problems associated with small OZ treatments against the risk of larger OZ treatments (e.g. corneal ectasia). In theory, combining a smaller OZ with a larger diameter transition (or blend) zone (TZ) using a more aspheric profile than normal may overcome some of the drawbacks inherent in the two individual approaches.

The purpose of this study was to assess the outcomes of small optical zone (OZ) ablations used in conjunction with large transition zones (TZ) and a highly aspheric treatment profile.

2. Methods

39 consecutive patients (71 eyes) in whom we had a complete dataset one year following surgery were assessed in this study. Ethical approval was obtained from the University of Ulster Local Research Ethics Committee. Information was collected on patients' pre and postoperative visual acuity, refraction, pupillometry and

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corneal topography/aberrometry. Surgery had been performed by a single surgeon (SS) on a Nidek EC-5000 CXIII excimer laser platform (Gamagori, Japan) with a Nidek MK-2000 microkeratome (in the LASIK patients) and using a wavefront guided aspheric enhanced peripheral ablation profile (optical path difference custom ablation treatment – OPDCAT). This profile allows a relatively small diameter OZ (down to 3 mm) with a large TZ (up to 10 mm); the typical values used in our study were 4.5 mm and 8.1 mm, respectively. The OZ/TZ were based on mesopic pupil size. All OZs were smaller than mesopic pupil and TZs were greater than 1 mm larger than the mesopic pupil diameter.

The patients' satisfaction with the outcome of the surgery was assessed by means of a questionnaire (annex A). The questionnaire was a simplified version of that used by the Council for Refractive Surgery Quality Assurance® in the United States (with their written permission) focusing specifically on patients' assessment of the quality of their day and night time vision and whether they suffer with dysphotoptic symptoms (glare, ghosting, haloes or starbursts). Pictorial examples of these dysphotopsias were used in the questionnaires to ensure accurate description of the symptoms. Quality of day and night vision was assessed as either much better than expected, better than expected, as expected, worse than expected and much worse than expected. The patients' symptoms of glare, ghosting, halos and starbursts were assessed as never, occasionally, most of the time or constantly.

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.clae.2013.02.010.

The patients were also asked about their need to wear glasses for near or distance after surgery and postoperative symptoms of dry eye and light sensitivity. The dysphotopic symptoms were ranked based on intensity (never = 1, some of the time = 2, most of the time = 3 and constant = 4) and an average intensity score was calculated per participant in the study.

The topography, aberrometry and pupillometry data was captured with the Nidek OPD Scan (Gamagori, Japan) and the scan image was analysed using Nidek Final Fit™ software (V1.15) to measure the postoperative effective optical zone (EOZ) and to look at the differences between the predicted postoperative topographic OZ (Final Fit™ simulation) and the actual postoperative topographic optical zone. Nidek's OPD Station™ software was used to calculate the pre and postoperative central corneal asphericity (*Q* values).

In the analysis of the Final Fit™ difference map (showing the difference between the predicted target topography and the actual postoperative topography) the difference readings from 3 areas were assessed: the centre, at the edge of the planned OZ and in the area between the edge of the EOZ and mid way into the TZ. These measurements were taken along the horizontal meridian on the temporal side.

2.1. Statistical analysis

The database contained a large number of different types of variables and as a result a variety of different tests were used when looking for relationships between the variables. Dysphotoptic symptoms were analysed for each patient as the mean value of both eyes where there was bilateral surgery. The mean sphere, cylinder and standard errors were plotted of the refractive outcome for individual eyes (71 eyes in total). Kendall's coefficient of concordance and Friedman's Analysis were used to check for associations between individual patients' ranking of symptoms. Any nominal data was compared using the two-tailed Fisher's exact test. Ordinal data was compared using Kruskal's Gamma test, which measures strength of association. A non-parametric Spearman's correlation test was used to compare continuous data.

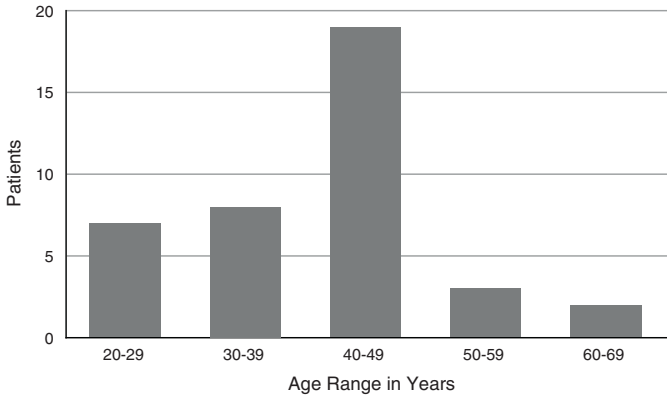

Fig. 1. Age distribution of patients.

Comparison between different types of variables, e.g. nominal/ordinal vs. continuous or ordinal vs. nominal, were carried out using Kruskal–Wallis (non-parametric) test to determine if they were similar. This test allowed the comparison of different dysphotoptic symptoms with pupil diameter, OZ size and postoperative spherical equivalent and defocus equivalent. Independent *t*-tests were used to compare the mean values for OZ size, EOZ size and *Q*-values between 2 groups of patients, those with dysphotoptic symptoms and those without.

3. Results

A complete dataset one year following surgery was available in 39 of the questionnaire respondents (71 eyes) for analysis in the study. The questionnaire itself had a response rate of 51% which was deemed acceptable for this type of questionnaire and there was no statistical difference in reported symptoms of dysphotopsias in early and late respondents (an indicator of possible non-response bias) [6,7]. The age range of the patients was 21–66 years (mean age 40.7 ± 10.4 years, see Fig. 1); the mean preoperative spherical equivalent (SE) was −4.50 ± 2.11 dioptres (D) (range −0.25 to −8.75 D) and the mean cylindrical correction was 1.10 ± 0.84 dioptres (range 0–3.25). Of the 39 patients all but 7 had both eyes treated, 13 had LASIK (mean SE = −5.41 ± 2.15 D; range −0.75 to −9.25) and 26 had LASEK (mean SE = −3.60 ± 1.81 D; range −0.25 to −7.00). The refractive outcome results for the 71 eyes are presented in Fig. 2A–F.

The mean planned OZ diameter was 4.5 ± 0.5 mm (range 3.8–5.5 mm) and the mean TZ diameter was 8.1 ± 0.4 mm (range 7.5–9.0 mm). The mean OZ diameters were the same in the LASIK and LASEK groups but the mean TZ diameters were statistically different, the LASEK group being slightly larger at 8.2 ± 0.4 mm (range 7.5–9.0 mm) compared to 7.9 ± 0.4 (range 6.5–8.5 mm) in the LASIK group.

3.1. Quality of vision

An overview of the satisfaction results for the 39 patients is shown in Table 1. The results in this section were all analysed with Kruskal's Gamma test. Dissatisfaction with the quality of daytime vision and the quality of night vision were shown to be closely linked ($p = 0.00$) in the 39 respondents. In addition dissatisfaction with the quality of daytime vision was associated with the need to wear distance glasses postoperatively ($p = 0.05$)