Objective: To investigate the effect of cataract extraction on the visual fields of patients with open-angle glaucoma.

Methods: Patients in a prospective cohort study in a tertiary center underwent standard automated perimetry every 6 months. We compared the mean results of the 2 examinations immediately before and 2 examinations immediately after phacoemulsification cataract extraction and intraocular lens implant (effect analysis) and the mean results of the first 2 and last 2 examinations from 4 consecutive examinations obtained more than 1 year after the cataract surgery (control analysis).

Results: Our sample contained 34 eyes of 26 patients (mean ± SD age, 69.2 ± 10.8 years). While the mean log-MAR best-corrected visual acuity improved significantly by approximately 2 Snellen lines after surgery (P = .001), the average change in mean deviation in both the effect and control analyses was less than 0.1 dB and not statistically significant (P = .85). There was a strong correlation between change in foveal sensitivity and change in mean deviation in the effect analysis but not in the control analysis (r = 0.76 [P < .001] and r = 0.30 [P = .08], respectively). There was no relationship between change in visual acuity or initial mean deviation and change in mean deviation in either analysis. Change in pointwise total deviation was not systematically related to the respective baseline value in either analysis; however, the variance of the distribution of change in total deviation was significantly higher in the effect analysis (P < .001).

Conclusion: While there was an improvement in best-corrected visual acuity after cataract surgery, the changes in the visual field as a group were negligible.


Static automated perimetry is a well-established and essential tool in the diagnosis and long-term management of glaucoma. The development of cataract in patients with glaucoma may exacerbate the visual field loss and may make it difficult to distinguish between visual field changes due to cataract and those due to the progression of glaucoma.

Cataracts are thought to cause visual degradation by 3 mechanisms: image blur, light scattering, and decreased illumination. Investigation of the effect of cataract or light scattering (simulated cataract) on the visual field has generally shown that cataract results in diffuse reduction of sensitivity in healthy subjects. Although the pattern of sensitivity loss may not be entirely uniform across the visual field, predominantly localized field loss such as that frequently seen in glaucoma is unlikely to be related to cataract.

The effect of cataract surgery on the visual field has been studied previously in healthy subjects and glaucoma patients using manual and automated perimetry. In studies with glaucoma patients, there was a range of visual field damage and the density of cataract, and while most studies found an increase in visual field sensitivity after cataract surgery, there is considerable variance in the results, with some studies showing a meaningful effect and others showing a modest or no effect.

In this study, we report the effect of cataract extraction on a group of glaucoma patients followed up in a longitudinal prospective study. In contrast to other studies, we computed a mean of 2 fields before and after surgery and used a paired control analysis in the same eyes to correct for any possible regression to the mean effect and visual field progression.
Informed consent was obtained from all subjects, and the tenets of the Declaration of Helsinki were followed.

In the effect analysis, we compared the mean results of the 2 visual fields immediately before and immediately after surgery. In the control analysis, the mean results of the first 2 and last 2 field examinations from 4 consecutive examinations obtained more than 1 year after surgery were compared. In this case, the first 2 fields constituted the equivalent of the presurgery fields and the latter 2 the postsurgery fields. Visual field data were averaged by computing the mean pointwise total deviation (TD). The visual acuity data were averaged corresponding to the dates of the visual field examinations. We examined pointwise and global changes in TD stratified according to the respective baseline values. The mean and standard deviation of TD yielded the unweighted MD and pattern standard deviation indexes, respectively. To study the influence of visual field eccentricity on pointwise TD, the visual field was divided into 2 zones: zone 1, stimuli within 16° eccentricity; and zone 2, stimuli outside 16° eccentricity. To study the effect of baseline pointwise TD on the change in TD in the effect and control analyses, the data were binned across all patients in 5-dB steps centered on −30 dB, −25 dB, and so on.

The presurgery and postsurgery data were compared using either a paired t test or a Wilcoxon matched-pairs signed rank test. P < .05 was considered statistically significant.

### METHODS

Data for this study were obtained from a longitudinal prospective study that began in September 1991, in which various psychophysical tests and scanning laser tomography were performed in a group of patients with open-angle glaucoma. Patients were recruited consecutively from the practice of one of us (R.P.L.) and the Glaucoma Clinic of the Eye Care Centre of the Queen Elizabeth II Health Science Centre, Halifax.

Inclusion criteria were as follows: (1) best-corrected visual acuity of at least 6/12; (2) diagnosis of open-angle glaucoma with glaucomatous optic disc damage, such as notching or progressive thinning of the neuroretinal rim and visual field damage with an initial mean deviation (MD) between −2 and −10 dB; (3) open angles by gonioscopy; and (4) willingness to participate in the study and to give informed consent. Exclusion criteria were as follows: (1) concomitant chronic ocular disease; (2) refractive error exceeding 5 diopters (D) spherical equivalent or 3 D of astigmatism; (3) aphakia; (4) systemic disease or systemic medication known to affect the visual field or ability to participate in the study; (5) chronic ocular medication other than for glaucoma; and (6) contact lens wear. All eyes included in this study underwent phacoemulsification cataract extraction and intraocular lens implantation alone or in combination with trabeculectomy, and had at least 2 visual field results available within 1 year before surgery and at least 6 visual field results available after surgery. Visual field examinations were performed with static automated perimetry using the 30-2 or 24-2 full-threshold algorithm (Humphrey Field Analyzer; Carl Zeiss Meditec, Dublin, Calif) every 6 months with the appropriate refractive correction. For a given patient, the same test (ie, 30-2 or 24-2) was used throughout the follow-up. The study protocol was approved by the Research Ethics Committee of the Queen Elizabeth II Health Science Centre.

Thirty-four eyes of 26 patients (mean±SD age, 69.2±10.8 years) were included in the study. In the effect analysis, the mean±SD time between the first visual field examination before surgery and the last visual field examination after surgery was 19.9±6.8 months, while that in the control analysis was 17.3±6.6 months.

Thirty (88%) of the 34 eyes underwent phacoemulsification cataract surgery with intraocular lens implantation, while 4 (12%) underwent combined phacoemulsification cataract surgery with intraocular lens implantation and trabeculectomy

The mean logMAR best-corrected visual acuity improved significantly (P < .001) from a mean of 0.24 (range, 0.00-0.48) to 0.07 (range, 0.00-0.33), or approximately 2 Snellen lines of visual acuity, after surgery (Figure 1A). Two (6%) of the eyes had a poorer postsurgical visual acuity. One of these eyes developed cystoid macular edema after surgery, which subsequently resolved. In the control analysis, the change in visual acuity was not statistically significant (from 0.06 [range, −0.06 to 0.30] to 0.09 [range, −0.06 to 0.33], P = .08) (Figure 1B).

In the effect analysis, there was no significant change in MD (mean±SD from −6.74±3.75 to −6.68±3.96 dB, P = .85) (Figure 2A). In the control analysis, the change in MD was almost identical (mean±SD from −6.46±4.15 to −6.38±4.19 dB, P = .67) (Figure 2B). There were also no significant changes in pattern standard deviation in either the effect or control analyses (mean±SD from 4.90±2.52 to 4.52±2.51 dB [P = .42] and from 4.43±2.38 to 4.37±2.51 dB [P = .24], respectively).

There was a strong positive correlation between change in foveal sensitivity and MD in the effect analysis (r = 0.76, P < .001) (Figure 3A), while that in the control analysis was much weaker (r = 0.30, P = .08) (Figure 3B). No
correlations were found between change in visual acuity or baseline MD and change in MD ($r = -0.42 \ [P = .41]$ and $r = -0.13 \ [P = .46]$ in the effect and control analyses, respectively [Figure 4] and $r = -0.20 \ [P = .26]$ and $r = 0.001 \ [P = .99]$ in the effect and control analyses, respectively [Figure 5]).

The distributions of the change in pointwise TD in the effect and control analyses were significantly different, with the variance in the effect analysis being significantly higher compared with the control analysis (3.51 and 2.90 dB, respectively; $P < .001$, Levene test). These differences persisted when the analysis was stratified according to visual field eccentricity (3.33 and 2.60 dB, respectively, in zone 1, and 3.60 and 3.05 dB in zone 2, respectively; $P < .001$).

There seemed to be no systematic dependence of the change in pointwise TD on the baseline pointwise TD in either the effect or control analysis (Figure 6). There were no significant differences between the 2 analyses except when the baseline TD centered at $-20\,\text{dB}$, where the improvement in TD seemed to be better in the control analysis ($P < .03$), and when it centered at $-10\,\text{dB}$, where the improvement in TD seemed to be better in the effect analysis ($P < .001$).

**COMMENT**

Changes in the visual field due to cataract are thought to confound those due to glaucoma. We performed this analysis on a group of patients followed up prospectively in a research study and who at baseline had early to moderate visual field damage. We elected to compare the mean results of 2 visual fields presurgery and 2 visual fields post-surgery rather than use single test results to decrease the impact of variability and any possible regression to the mean effect. We also performed an identical control analysis after the surgery to correct for potential visual field progression during the time elapsing between visual field results before and after surgery. Our results indicate that there was a significant increase in visual acuity after cataract surgery. The effect of surgery on the visual field in the group as a whole was negligible, although there was considerable individual variation.

Many reasons can guide the decision to perform cataract surgery, among them a decline in visual acuity and/or contrast sensitivity, glare, diplopia, and factors related to patient lifestyle. Specifically in glaucoma patients, the desire to better monitor the disease is a significant factor. The fact that the mean presurgery logMAR best-corrected visual acuity was 0.24 (between 20/30 and 20/40) and the MD was $-6.7\,\text{dB}$ indicates that in contrast with most studies previously published in this area, our patients had cataracts with lesser impact on high-contrast acuity and milder visual field damage.

Our results indicate that the variability of the change in the visual field using global and pointwise analysis was higher in the effect analysis compared with the control analysis. This finding suggests that the presence of cataract increases visual field variability and further that the...
changes in visual field caused by cataract removal may have been blunted by increased variability. Our decision to compute mean results of 2 examinations was an attempt to offset the effects of variability but may have reduced the impact of cataract surgery on visual field change. In addition, it is possible that comparison of the visual field and visual acuity in examinations immediately before and after surgery may have shown a larger effect. While our study did not show a meaningful effect of cataract extraction on the group as a whole, in clinical practice it is probably still prudent to reestablish the baseline after surgery because the effect of surgery in individual patients was somewhat variable.

Several investigators have studied the effect of cataract on static automated perimetry. Guthauser and Flammer found a diffuse effect of cataract on the visual field in a group of glaucoma and nonglaucoma patients. Chen and Budenz found that the improvement in MD after cataract surgery depended on the level of glaucomatous field loss, with patients with more severe loss showing more modest improvement. Differences between their findings and ours may relate to the more advanced level of visual field loss in their series (mean ± SD baseline MD, −14.5 ± 5.4 dB vs. −6.7 ± 6.1 dB in the present study). Hayashi and Smith found improvements in MD, even in subjects with dense scotomata. Their studies included patients with more advanced glaucoma presurgery as well (mean ± SD MD, −17 ± 7.81 dB in 78% of patients in the former study and −14.19 ± 6.9 dB in the latter study). Similar to our results, Stewart and associates found no appreciable change in either MD or pattern standard deviation after cataract surgery. They attributed their results to the generally advanced level of visual field loss (63% of eyes had MD worse than −17.0 dB). Apparently, no causal relation between the extent of glaucomatous visual field damage presurgery and the potential effect of cataract surgery on the visual field can be consistently implied because while our patients had on average early visual field damage, those from the study by Stewart and associates had advanced visual field loss and yet the outcomes were comparable.

The differential effect of cataract in the central and peripheral areas of the visual field has also been reported. Lam et al found a significant effect of cataract surgery in the central region, contrasting with a relatively minor effect in the periphery by dividing the visual field into 4 concentric zones for analysis. Similar results were found by other researchers. Chen and Budenz calculated the percentage of change of the foveal sensitivity and MD by expressing the absolute change in decibels as a fraction of the original value of the variable. In our study, we were unable to demonstrate zone-specific differences in TD after cataract surgery.

A potential weakness of our study was the lack of clinical grading of cataracts. However, some studies have revealed that heterogeneity of cataracts limits the correlation between staging of cataracts by experienced clinicians or by light scatter measurement and visual field loss.

In summary, the present study demonstrates that while there was an improvement in best-corrected visual acuity after cataract surgery, the changes in the visual field in the group as a whole were negligible. There was, however, interindividual variation in visual field change after cataract surgery, implicating the exacerbating effects of cataract on visual field variability. Further prospective controlled studies with a clearly defined and standardized grading system for cataract are necessary to determine and more clearly interpret the effect of the different types of cataract on the visual field in the whole spectrum of glaucoma patients.

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