The Importance of Acuity, Stereopsis, and Contrast Sensitivity for Health-Related Quality of Life in Elderly Women with Cataracts

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PURPOSE. To investigate the relative contribution of visual and other factors to quality of life among elderly women with bilateral cataract.

METHODS. Data were analyzed from a trial of first-eye cataract surgery. Visual parameters, general health, and social variables, and disease-specific (VF-14 Index of Visual Function), generic (Euroqol: EQ-5D, London Handicap Scale, Barthel), and intermediate (anxiety, depression, and activity) outcomes were measured at baseline and 6 months later, when approximately half the group had had surgery.

RESULTS. Three hundred six participants provided data at baseline, and 289 at 6 months. At baseline, acuity, stereopsis, and contrast sensitivity were all associated with quality of life. Acuity and stereopsis were most strongly and consistently associated. Change in VF-14 was associated with changes in stereopsis and contrast sensitivity, while change in handicap was associated with change in stereopsis.

CONCLUSIONS. Acuity, stereopsis, and contrast sensitivity each contributed to quality of life, across a range of measures, in elderly women with cataract. Acuity was marginally the most consistently and generally the most strongly associated, but in some analyses stereopsis was more important. Change in quality of life was associated with change in stereopsis and contrast sensitivity. (isrctn.org number, ISRCTN03184072) (Invest Ophthalmol Vis Sci. 2008;49:1–6) DOI:10.1167/iovs.06-1073

Cataract is not a life-threatening condition, and the purpose of surgery is to reduce visual disability and improve patients’ health-related quality of life—defined as the individual’s subjective perception of the value or worth of his or her state of health. It is a multidimensional concept including physical, psychological, and social elements.

There is no single gold-standard measure of quality of life. Different scales attempt to classify quality of life in one number (e.g., Euroqol; EQ-5D, London Handicap Scale, Barthel) or to provide a profile of aspects of quality of life (e.g., SF-36; Medical Outcomes Trust, Waltham, MA). Measures may be generic, measuring across different health conditions, or disease-specific, and therefore more likely to detect subtle effects. Other scales measure specific aspects of quality of life, such as functional ability or psychological status.

First-eye cataract surgery has established benefits for visual function, particularly better postoperative visual acuity. These benefits also translate into improved visually related daily activities (for example, measured by the Visual Function [VF]-14). First eye cataract surgery also results in improvements in generic quality of life measures, such as Euroqol and the London Handicap Scale, and significant improvements in anxiety, depression, and confidence, compared with nonsurgical controls.

Acuity is associated with quality of life before surgery, but it has been suggested that other parameters, such as stereopsis or contrast sensitivity, are more important than acuity, especially since many cataract patients have relatively good acuity at baseline.

In this study we sought to determine which factors contribute most to quality of life among patients with preoperative cataract and which visual factors best explain change in quality of life over time.

METHODS

We undertook a secondary analysis of data from a randomized controlled trial of first-eye cataract surgery, comparing expedited surgery (within a month of randomization), with wait-list control subjects (who had surgery approximately 12 months after randomization, reflecting the usual experience of National Health Service patients in the United Kingdom at the time of the trial).

Participants

We studied 306 women older than 70 years, with bilateral cataract, who had not had ocular surgery and who were suitable for surgery by phacoemulsification. Patients were excluded if at risk of postoperative anisometria (best spherical equivalent outside the range of +4 to −6 DS), if they had visual field defects or comorbid eye disease severely affecting acuity, or had very poor vision (6/36 or worse, making it unethical to delay surgery) and those with memory problems preventing completion of questionnaires. All participants gave informed written consent. The study was approved by the local Research Ethics Committee and adhered to the tenets of the Declaration of Helsinki.
Measurements

Baseline information was collected by interview on demographic and social variables, comorbid diagnoses, cognitive function, prescribed drugs, and social support. Ophthalmic history included the use of glasses and other ocular problems. Examination, under standard conditions, included refraction, visual acuity (binocular, with current spectacles, recorded as logMAR, with an EDTRS-modified Bailey-Lovie chart, Precision Vision, Villa Park, IL), contrast sensitivity with a Pelli-Robson chart (Clement Clarke, Harlow, UK); stereopsis with the Wirt Fly and Frisby system (Clement Clarke), which we used down to 150 seconds of arc.

Outcome measures were activity, anxiety, and depression, activities of daily living (Barthel Index), visual disability (VF-14), handicap (London Handicap Scale), and overall quality of life (Euroqol, EQ-5D). The activity score is an estimate of energy expended during domestic and leisure tasks. The Hospital Anxiety and Depression Scales are designed for use in physical disease, as they concentrate on psychological rather than physical symptoms. The VF-14 contains 14 activities dependent on visual function and is validated for use in patients with cataract. The Euroqol has six items, mobility, self-care, usual activities, pain and anxiety/depression. The London Handicap Scale has six items based on WHO handicap (participation) dimensions (mobility, independence, occupation, social integration, awareness and economic). Both are utility weighted (scores are estimates of subjective value of the health state).

Ophthalmic and outcome measurements were made at baseline and repeated 6 months after randomization, when approximately half the group had had surgery and half had not.

Statistical Analysis

The population was described in terms of distributions of baseline variables. We used linear regression to examine univariate associations between baseline measurements of exposure variables and measures of quality of life (VF-14, London Handicap Scale, Euroqol, anxiety and depression, activity and Barthel Index). These variables were checked for normal distribution and homoscedasticity (assumptions for performing linear regression). The exposure variables included visual parameters (spectacle-aided acuity, stereopsis, contrast sensitivity, refraction, and use of glasses), age, body mass index, marital status, living alone, income, social support deficits, and general health status (number of comorbid diagnoses, number of prescribed drugs, Mini Mental State Examination score, history of falls in the past 12 months, and dizziness on standing). We estimated the relative strengths of association between variables by using the standardized regression coefficient (standardized beta, the standard deviation–scaled change in outcome per standard deviation change in exposure variable).

We used multiple linear regression to adjust for potential confounding effects, by modeling potentially confounding baseline nonvisual variables (those with a univariate association at \( P < 0.25 \)) and then adding visual variables separately.

For surgically treated participants only, we modeled the association between changes in exposure (visual acuity, contrast sensitivity, and stereopsis) and outcome (VF-14, LHS, Euroqol, activity, anxiety, and depression) variables by regression analyses. The dependent variable was the follow-up outcome measurement, with the baseline value included as an independent variable (to correct for regression to the mean). We performed multivariate analyses as for the baseline associations.

We examined two-way interactions between visual and potential confounding factors. Since many participants had good stereopsis at baseline we repeated analyses on the subgroup with stereopsis worse than 150 seconds of arc. We also repeated the analysis using corrected acuity in the worse eye.

RESULTS

One hundred fifty-four participants were randomized to expended surgery and 152 were control subjects. Two hundred eighty-nine were followed up after 6 months (median, 185 days; range, 126–256). Before follow-up, two patients died, eight (3%) withdrew or were lost, and six (2%) had surgery outside the trial. Age ranged from 70 to 94 years. The population was moderately frail; on average, each patient had eight comorbid diagnoses and was taking four prescribed drugs; half had fallen in the year before randomization (Table 1). Most were widows (57%) and lived alone (60%); 11% drove a car. Heart problems were reported by 31%, chest problems by 20%, arthritis by 76%, and a history of stroke by 7%. There were no major baseline differences between participants randomized to each arm of the study.

The median baseline spectacle-corrected binocular acuity was 0.28 logMAR units (interquartile range, 0.16–0.42), equivalent to 6/11 Snellen fraction. Half of participants had good baseline stereopsis (150 seconds of arc). Only 8.5% were unable to perceive the Wirt Fly (implying stereopsis worse than 1000 seconds of arc). Median log contrast sensitivity was 1.35 (range, 0.05–1.95). Median refraction (magnitude of best spherical equivalent) was 1.69 D, differing by 0.75 D between the two eyes on average.

The outcome variables Euroqol, London Handicap Scale, and VF-14 were grouped toward the upper ends of their ranges. Baseline activity scores were skewed toward the lower end and were log transformed. The Euroqol scores varied from −0.08 to 1.0, and they were transformed by the equation: Transformed Euroqol = Log_{10} (Baseline Euroqol +1.08), 1.08 being a constant added to give positive scores for logarithmic function. This substantially improved kurtosis and skew in both cases. Other variables were approximately normally distributed and did not require transformation.

Visual acuity, contrast sensitivity, stereopsis were moderately correlated at baseline (Spearman’s rho 0.41 for acuity-contrast, 0.21 for acuity-stereopsis; 0.30 for contrast-stereopsis). Changes over 6 months were similarly correlated (Spearman’s rho 0.51 for acuity-contrast; 0.18 for acuity-stereopsis; 0.17 for contrast-stereopsis).

In univariate analyses baseline VF-14 was strongly associated with acuity, stereopsis, and contrast sensitivity, with acuity the strongest. Difference in refraction between eyes was significantly, but less strongly, associated. Associated nonvisual factors included number of prescribed drugs, falls history, and postural dizziness. Number of drugs was associated as strongly as the visual variables. There was no association with any specific drug type.

The Baseline London Handicap Scale showed a slightly different pattern of univariate associations. Acuity, stereopsis, and contrast were all significantly associated, but less strongly than for VF-14. Stereopsis was most strongly associated. As expected for a generic scale, more nonvisual factors were associated, including age, marital status, income, and general health measures (number of prescribed drugs, comorbidities, falls and cognition). Number of drugs was overall the most strongly associated variable.

Stereopsis was also most strongly associated with activity, but acuity and contrast were also significant. Only acuity was associated with depression and Barthel Index. No visual variables were significantly associated with Euroqol or anxiety. General health and social factors were important: notably, falls for activity, anxiety and Barthel Index; social support deficits for depression; and age, comorbidity, and body mass index for activity. Number of prescription drugs was consistently and strongly associated with all the outcomes.

In multivariate models of quality of life at baseline, coefficients were very similar to univariate results, indicating the absence of significant confounding effects (Table 2). All three visual variables remained associated with VF-14, handicap, and activity. Acuity was most strongly associated with VF-14, acuity.
DISCUSSION

We looked at the effect of vision on quality of life in two ways. The first was a cross-sectional survey of patients entering a randomized trial of cataract surgery. The second was change in quality of life over time in those who had had cataract surgery. Our findings are complicated, but show that each of the main determinants of generic quality of life.

In baseline analyses, acuity was marginally the most consistently and strongly associated visual variable. However, stereopsis was also consistently important, and in some individual analyses (handicap, activity) was at least as strongly associated as acuity. Contrast sensitivity was only associated with some of our quality of life outcomes (VF-14, handicap) and more weakly. However, in the analysis of change over time, change in stereopsis and contrast sensitivity showed the only significant associations.

The importance of acuity is not surprising, reflecting its usefulness in daily visual activities, such as reading. Other studies have also found acuity to be an important factor in quality of life (for example, Refs. 16, 19–21).

Interpretation may not be as simple as this, however. Many of the items in the VF-14 are directly dependent on acuity (reading labels or signs, doing fine handwork). Acuity was less important than either stereopsis or contrast for activity and Euroqol, whereas stereopsis was as important as acuity for handicap. This may suggest that acuity is required for functional tasks, but stereopsis and contrast were more important determinants of generic quality of life.

Stereopsis is the use of binocular clues to perceive depth, and it requires good vision in both eyes and bilateral intact visual pathways to operate. There are many monocular clues to depth perception (motion parallax, retinal image size, overlapping contours, convergence and accommodation, and the use of lights and shadows). Accordingly monocular patients are able to compensate for loss of stereopsis. There has been little work on how stereopsis affects visual quality of life, but functional deficits can be demonstrated in patients who lack stereopsis on psychophysical testing. One previous study concluded that stereopsis had no effect on visual tasks, but was associated with the energy/vitality dimension of the SF-36.22 One would anticipate that functional deficit would be greatest for fine motor tasks (e.g., threading a needle) but most evi-
Table 2. Multivariate Models for Visual Variables at Baseline

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Postural dizziness</td>
<td>0.16 (0.05) 0.005</td>
<td>-0.26 (0.05) &lt;0.001</td>
<td>-0.41 (0.05) &lt;0.001</td>
<td>-0.43 (0.04) &lt;0.001</td>
<td>-0.38 (0.06) &lt;0.001</td>
<td>-0.13 (0.06) 0.05</td>
<td>-0.31 (0.06) &lt;0.001</td>
</tr>
<tr>
<td>Number of drugs</td>
<td>-0.11 (0.05) 0.04</td>
<td>-0.15 (0.05) 0.1</td>
<td>-0.41 (0.05) &lt;0.001</td>
<td>-0.43 (0.04) &lt;0.001</td>
<td>-0.16 (0.05) 0.003</td>
<td>0.19 (0.06) 0.001</td>
<td>0.27 (0.06) &lt;0.001</td>
</tr>
<tr>
<td>Age</td>
<td>0.13 (0.05) 0.02</td>
<td>0.13 (0.05) 0.01</td>
<td>-0.43 (0.04) &lt;0.001</td>
<td>-0.16 (0.05) 0.003</td>
<td>-0.10 (0.05) 0.05</td>
<td>0.19 (0.06) 0.001</td>
<td>0.27 (0.06) &lt;0.001</td>
</tr>
<tr>
<td>Lives alone</td>
<td>Corrected VA</td>
<td>-0.32 (0.06) &lt;0.001</td>
<td>-0.16 (0.05) 0.003</td>
<td>0.01 (0.05) 0.83</td>
<td>-0.13 (0.05) 0.02</td>
<td>0.01 (0.06) 0.87</td>
<td>0.14 (0.06) 0.01</td>
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<tr>
<td>Social support deficits</td>
<td>0.13 (0.06) 0.02</td>
<td>0.13 (0.05) 0.01</td>
<td>-0.43 (0.04) &lt;0.001</td>
<td>-0.15 (0.05) 0.01</td>
<td>-0.13 (0.06) 0.03</td>
<td>0.19 (0.06) 0.001</td>
<td>0.26 (0.06) &lt;0.001</td>
</tr>
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<td>Postural dizziness</td>
<td>-0.25 (0.06) &lt;0.001</td>
<td>-0.41 (0.05) &lt;0.001</td>
<td>-0.43 (0.04) &lt;0.001</td>
<td>-0.15 (0.05) 0.01</td>
<td>-0.13 (0.06) 0.03</td>
<td>0.19 (0.06) 0.001</td>
<td>0.26 (0.06) &lt;0.001</td>
</tr>
<tr>
<td>Number of drugs</td>
<td>-0.14 (0.05) 0.01</td>
<td>-0.41 (0.05) &lt;0.001</td>
<td>-0.43 (0.04) &lt;0.001</td>
<td>-0.15 (0.05) 0.01</td>
<td>-0.13 (0.06) 0.03</td>
<td>0.19 (0.06) 0.001</td>
<td>0.26 (0.06) &lt;0.001</td>
</tr>
<tr>
<td>Age</td>
<td>0.16 (0.05) 0.001</td>
<td>0.05 (0.05) 0.37</td>
<td>0.11 (0.05) 0.05</td>
<td>0.03 (0.06) 0.60</td>
<td>-0.06 (0.06) 0.26</td>
<td>0.05 (0.06) 0.40</td>
<td></td>
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<tr>
<td>Social support deficits</td>
<td>0.21 (0.06) &lt;0.001</td>
<td>0.10 (0.05) 0.05</td>
<td>0.05 (0.05) 0.37</td>
<td>0.11 (0.05) 0.05</td>
<td>0.03 (0.06) 0.60</td>
<td></td>
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<tr>
<td>Contrast sensitivity</td>
<td>0.01 (0.05) 0.02</td>
<td>0.13 (0.05) 0.02</td>
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<tr>
<td>Postural dizziness</td>
<td>-0.25 (0.06) &lt;0.001</td>
<td>-0.40 (0.05) &lt;0.001</td>
<td>-0.43 (0.04) &lt;0.001</td>
<td>-0.37 (0.05) &lt;0.001</td>
<td>0.19 (0.06) 0.001</td>
<td>0.26 (0.06) &lt;0.001</td>
<td>0.31 (0.06) &lt;0.001</td>
</tr>
<tr>
<td>Number of drugs</td>
<td>-0.16 (0.05) 0.002</td>
<td>-0.41 (0.05) &lt;0.001</td>
<td>-0.43 (0.04) &lt;0.001</td>
<td>-0.37 (0.05) &lt;0.001</td>
<td>0.19 (0.06) 0.001</td>
<td>0.26 (0.06) &lt;0.001</td>
<td>0.31 (0.06) &lt;0.001</td>
</tr>
<tr>
<td>Age</td>
<td>-0.12 (0.05) 0.03</td>
<td>-0.16 (0.05) 0.002</td>
<td>-0.43 (0.04) &lt;0.001</td>
<td>-0.37 (0.05) &lt;0.001</td>
<td>0.19 (0.06) 0.001</td>
<td>0.26 (0.06) &lt;0.001</td>
<td>0.31 (0.06) &lt;0.001</td>
</tr>
<tr>
<td>Lives alone</td>
<td>Social support deficits</td>
<td>0.13 (0.06) 0.02</td>
<td>-0.08 (0.05) 0.13</td>
<td>-0.20 (0.05) &lt;0.001</td>
<td>0.10 (0.06) 0.09</td>
<td>0.02 (0.06) 0.68</td>
<td>0.02 (0.06) 0.74</td>
</tr>
<tr>
<td>Stereopsis</td>
<td>-0.22 (0.06) &lt;0.001</td>
<td>-0.16 (0.05) 0.002</td>
<td>-0.08 (0.05) 0.13</td>
<td>-0.20 (0.05) &lt;0.001</td>
<td>0.10 (0.06) 0.09</td>
<td>0.02 (0.06) 0.68</td>
<td>0.02 (0.06) 0.74</td>
</tr>
</tbody>
</table>

Data are adjusted for age, postural dizziness, Mini Mental State Examination score, number of drugs, body mass index, living alone, and social support deficits. Visual variables and statistically significant (P < 0.05) nonvisual variables only are shown. Standardized regression coefficients (Standardized beta) for all other terms were < 0.05. There were no significant associations with MMSE or BMI in any of the final models, nor with living alone for the contrast sensitivity model. LHS, London Handicap Scale; SE, standard error.
dence relates to driving.\textsuperscript{25–29} Drivers with reduced stereocuity appear to be involved in more traffic accidents.

The importance of contrast sensitivity over acuity has been suggested\textsuperscript{31,27} with the rationale that the environment contains more low- than high-contrast visual stimuli.

Previous studies suggested that change in acuity is limited as a predictor of satisfaction with vision\textsuperscript{29} and of change in function (using the VF-14).\textsuperscript{29} One might expect lack of improvement in quality of life after acuity improves if patients have reasonable preoperative acuity, but this has not always been the case.\textsuperscript{30}

Most participants had reasonable baseline stereopsis, and so we may have underestimated its importance. However, we failed to show any greater effect in the subgroup with suboptimal initial stereopsis. We studied patients who had undergone surgery on one eye only, but have shown that first-eye surgery produced a greater change in stereopsis than second-eye surgery in this population.\textsuperscript{31,34} Presumably, baseline second-eye function was sufficient to permit stereopsis, despite the cataract. Several second-eye cataract studies have found benefits in visual function and quality of life,\textsuperscript{5,31,32} highlighting the effects of restored binocularity.

It is important to note that we have shown visual factors to be associated with generic as well as vision-specific quality-of-life measures. Depression has been reported to reduce scores on another visual function measure (the NEI VFQ-25), independent of visual status.\textsuperscript{35} However, the same group reported no benefit of cataract surgery on depression, contrary to our findings.\textsuperscript{4,34}

The weak and inconsistent effect of visual factors on Euroqol (which is very popular among health economists) is noteworthy. Vision is not included directly as an item in Euroqol EQ-5d, in which pain and anxiety/depression (both also important level factors, like vision) are included. Visually directed interventions are therefore likely to have less impact on the Euroqol and therefore may be less prioritized in health policy decisions. We suggest that the lack of responsiveness of the Euroqol to clinically significant changes in vision make it an inadequate instrument for measurement of vision-related quality of life.

Among the nonvisual factors that we studied, the association between number of prescribed drugs and all outcome measures at baseline was striking. We interpreted this as a proxy measure of comorbidity. It is perhaps superior to number of comorbidities (seemingly a more obvious indicator of health status) as drug prescription combines both number of problems, with an element of severity. Adverse effects of the drugs are a less likely explanation, given that no specific drug or drug-type reduced quality of life.

We studied only elderly women with bilateral cataracts. The primary focus of our trial was on falls and fractures, a particular problem for this group. Restriction by gender allowed us to avoid a potential source of confounding. Clearly this means that our results are only directly applicable to elderly women. Our main outcome measure was designed for use in patients with cataract (although its content covers fairly general visual tasks). It is possible that in other patient groups (for example, with more asymmetrical eye disease), or with a more depth perception-orientated outcome measure, different results may have emerged.

A further limitation of the study was that the strength of association between change in visual factors and change in quality of life may be underestimated, since baseline visual function was fairly good. Moreover, several outcome scales had ceiling effects (VF-14, London Handicap Scale, Barthel Index), which would make outcomes less responsive to the benefits of intervention. In the analyses of change regression to the mean effects might have distorted apparent relationships, although we corrected for this in our regression models.

### Acknowledgments

The authors thank Deborah Watmough and Jan Jones for helping to arrange data entry.

### References


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**Table 3. Relative Effect of Change in Visual Variables on Change in Quality of Life in Multivariate Analyses, among Surgically Treated Participants**

<table>
<thead>
<tr>
<th>Acuity</th>
<th>Stereopsis</th>
<th>Contrast Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standardized Beta</td>
<td>SE</td>
</tr>
<tr>
<td>VF-14</td>
<td>−0.14</td>
<td>0.08</td>
</tr>
<tr>
<td>LHS</td>
<td>−0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>Euroqol</td>
<td>0.07</td>
<td>0.03</td>
</tr>
<tr>
<td>Activity</td>
<td>−0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>Anxiety</td>
<td>−0.07</td>
<td>0.06</td>
</tr>
<tr>
<td>Depression</td>
<td>−0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>Barthel Index</td>
<td>−0.06</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Data are adjusted for age, Mini Mental State Examination score, number of drugs, postural dizziness and body mass index and for the baseline value of the quality of life variable. LHS, London Handicap Scale; SE, standard error.


