ARTICLE

Long-term outcomes of cataract surgery: 15-year results of a prospective study

Eva Mönestam, MD, PhD

PURPOSE: To describe the change over a 15-year period in corrected distance visual acuity (CDVA), subjective visual function, and neodymium:YAG (Nd:YAG) frequency after cataract surgery.

SETTING: Eye Clinic, Norrlands University Hospital, Umeå, Sweden.

DESIGN: Prospective longitudinal population-based cohort study.

METHODS: Patients who had cataract surgery during a 1-year period, 15 years previously (1997 to 1998), were included. All patients answered the same Visual Function-14 (VF-14) questionnaire preoperatively, 4 months postoperatively, and 5, 10, and 15 years after surgery. Most patients (88%; 168/190; 74% of survivors) also had an ocular examination. The CDVA was measured with logMAR charts.

RESULTS: The study included 190 patients (83% of survivors). Fifteen years after surgery, the median CDVA in the operated eye had deteriorated from 20/20 postoperatively to 20/25 ($P = .0001$). Sixty percent of the patients had worsening of CDVA of less than 0.1 logMAR units compared with postoperatively. Fifty-four percent (103/190) had no deterioration in subjective visual function (VF-14), and 79% (150/190) had 10 points of decline or less. Previous Nd:YAG laser capsulotomy was more common in those younger than 65 years at surgery (49% versus 25%) ($P = .002$).

CONCLUSIONS: The study confirms the effectiveness of cataract extraction, offering good long-term visual rehabilitation for the majority of the patients. The most common comorbidity causing large functional loss 15 years after surgery was age-related macular degeneration. Fifteen years after surgery, one half of the patients younger than 65 years at surgery had not required a posterior Nd:YAG laser capsulotomy.

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Even though cataract extraction is one of the most frequently performed surgical procedures, cataract is still a significant cause of visual impairment and legal blindness.[1–3] In some countries, incident cataract surgery has leveled off, but, in other countries, the rate of cataract surgery has increased steadily.[4,5] Cataract surgery is arguably the most cost-effective surgical procedure worldwide.[6] However, when large volumes are involved, the total cost to society is nevertheless substantial and the resultant treatment burden may influence the distribution of healthcare funding.[5]

Long-term follow-up is an important step in evaluating cataract surgery results because many patients have a remaining lifespan of several years or decades after cataract surgery. In the Western world, an increasing number of persons are projected to reach their 9th and 10th decades of life.[7] Follow-up longer than 10 years is of value also in the preoperative counseling of cataract surgery patients. The 10-year follow-up of the present cohort reported satisfactory outcomes regarding visual acuity and visual functional outcomes.[8] To the author's knowledge, no longitudinal prospective study of visual outcomes after phacoemulsification, extending to 15 years, has been published.

This study investigated longitudinal changes in cataract surgery outcomes during a 15-year period, focusing on changes in visual acuity and self-estimated visual

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function and frequency of neodymium:YAG (Nd:YAG) laser capsulotomy.

PATIENTS AND METHODS

Participants

Data for the current analysis were derived from a prospective population-based cohort study initiated in 1997 to 1998. Detailed methods of this cohort and inclusion and exclusion criteria and 5-year and 10-year results have been published.[8–10]

The study and data accumulation were carried out with prospective approval from the Ethics Committee of Umeå University, Umeå, Sweden, and followed all Swedish laws. The study also followed the tenets of the Declaration of Helsinki, and informed consent for the research was obtained from all participants at the beginning of each examination.

Main Outcome Measures

The main outcome measures were the corrected distance visual acuity (CDVA), Visual Function-14 (VF-14) questionnaire total score, main comorbidity if CDVA was worse than 20/25, and previous Nd:YAG laser capsulotomy.

Examinations

A few weeks before surgery, presenting visual acuity and CDVA were measured with a Monoyer–Granström visual acuity chart after subjective refraction. Presenting visual acuity is the distance visual acuity using the participant's habitual distance correction, if any. The eye examination also included anterior segment biomicroscopy, tonometry, and fundoscopy after dilation. The presence of any ocular comorbidity or past surgery was recorded. Approximately 4 to 8 weeks postoperatively, the visual acuity test and the eye examination were repeated. Each follow-up examination 5, 10, and 15 years postoperatively was performed in the same manner as baseline except that Early Treatment Diabetic Retinopathy Study (ETDRS) visual acuity methods were used. The exact date of the Nd:YAG capsulotomy was recorded, if performed.

Questionnaire

The questionnaire was based on the VF-14 questionnaire developed in the United States, which has been found appropriate for use also in Europe.[11] The VF-14 is a widely used patent-reported outcome instrument in ophthalmology developed to assess activity limitations in 14 vision-specific activities performed in everyday life.[12] An overall estimate of the visual function (the VF-14 score) is calculated and in the present study was calculated as originally described as a summary score.[13] The range of the VF-14 score is 0 to 100. A score of 0 denotes a very low visual function as a result of visual impairment, and 100 points represents unrestricted/unaffected subjective ability to perform the 14 vision-dependent activities included. The same questionnaire was answered a few weeks before surgery, 3 to 4 months postoperatively, and 5, 10, and 15 years after surgery.

Surgical Technique

In most cases, sutureless clear corneal phacoemulsification with a temporal incision and posterior chamber foldable intraocular lens (IOL) implantation were performed.

Vision Loss

Vision loss was defined as a corrected visual acuity worse than 20/25 (logMAR >0.1). The primary comorbidity was defined as the single condition that explained at least 50% of the vision loss. The same ophthalmologist (E.M.) examined all patients.

Statistical Analysis

Statistical Package for the Social Sciences for MS Windows software (21.0, SPSS Inc.) was used for all data analyses.

The visual acuity values from the Monoyer–Granström letter chart were converted into a log scale, as previously described.[14] When using the ETDRS chart 5, 10, and 15 years after surgery, visual acuity was scored as the total number of letters read correctly and transformed into the logMAR scale. Patients who could not read any letters were tested using counting fingers (CF), hand movements (HM), and light perception. For visual acuity less than CF 0.5 m, the following arbitrary logMAR values were used: CF in front of the eye = logMAR 2.2, HM = logMAR 2.5, and no light perception = logMAR 3 in a similar manner as previously used.[8]

The change in CDVA was calculated by subtracting the CDVA logMAR score 15 years after surgery from the 1- to 2-month postoperative CDVA logMAR score; a positive value indicated worse visual acuity after surgery. The same method was used for calculating the change in the VF-14 total score, but a positive value indicated improved visual function.

Independent-sample *t* tests were used to compare age differences and CDVA for participants and nonparticipants at the different examinations. Univariate analysis of variance (ANOVA) was used to control for age in the analysis of the change in CDVA over 15 years. Yate's corrected χ^2 tests were used to analyze the 2-by-2 tables when appropriate.

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From the Department of Clinical Sciences/Ophthalmology, Faculty of Medicine, Umeå University, Umeå, Sweden.

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Corresponding author: Eva Mönestam, MD, PhD, Department of Clinical Sciences/Ophthalmology, Faculty of Medicine, Umeå University, S-901 85 Umeå, Sweden. E-mail: eva.monestam@vll.se.

Table 1. Demographic and clinical data of participants who were examined (n = 168) and those participating on the questionnaire only (n = 22) at the 15-year follow-up.

Characteristic	Eye Examination (74% of Survivors)	Questionnaire Only (10% of Survivors)	*P* Value*
Age (y)			
At exam			
Mean	79.4	82.4	.21
95% CI	77.8, 81.0	77.1, 87.8	
At surgery (n)			
<60 y	44	5	
60 to 69 y	60	3	
70 to 79 y	60	13	
80 to 89 y	4	1	
Female sex (%)	70	73	.81
CDVA			
Preop			
In operative eye, n (%)			
20/30 or better	11 (7)	0	
20/40–20/32	16 (10)	6 (27)	
20/42–20/90	34 (20)	5 (23)	
20/100–20/200	55 (33)	5 (23)	
<20/200	52 (30)	6 (27)	
Mean logMAR	0.99	0.86	.41
95% CI	0.88, 1.09	0.57, 1.15	
Median	0.7	0.6	
(Q1:Q3)	0.5:1.4	0.3:1.27	
Postop (1–2 mo)			
In operative eye, n (%)			
20/30 or better	147 (88)	20 (92)	
20/40–20/32	8 (5)	1 (4)	
20/42–20/90	6 (3)	1 (4)	
20/100–20/200	5 (3)	0	
<20/200	1 (1)	0	
Mean logMAR	0.09	0.05	.40
95% CI	0.06, 0.13	0.0, 0.1	
Median	0.0	0.0	
(Q1:Q3)	0:0.1	0:0.1	
Postop (5 y)			
In operative eye, n (%)			
20/30 or better	133 (79)	14 (64)	
20/40–20/32	17 (10)	4 (18)	
20/42–20/90	7 (4)	3 (14)	
20/100–20/200	6 (4)	1 (4)	
<20/200	5 (3)	0	
Mean logMAR	0.12	0.14	.81
95% CI	0.07, 0.18	0.05, 0.23	
Median	0.04	0.09	
(Q1:Q3)	−0.04:0.14	−0.02:0.26	
Postop (10 y)			
In operative eye, n (%)			
20/30 or better	123 (79)	14 (88)	
20/40–20/32	12 (8)	1 (6)	
20/42–20/90	11 (7)	1 (6)	
20/100–20/200	5 (3)	0	
<20/200	5 (3)	0	
Missing cases	12 (7)	6 (27)	
Mean logMAR	0.13	0.08	.61
95% CI	0.07, 0.19	−0.02, 0.18	
Median	0.02	0.05	
(Q1:Q3)	−0.06:0.14	0.02:0.12	
Postop (15 y)			
In operative eye, n (%)			
20/30 or better	119 (71)	—	
20/40–20/32	17 (10)	—	
20/42–20/90	10 (6)	—	
20/100–20/200	8 (5)	—	
<20/200	14 (8)	—	
Mean logMAR	0.29	—	
95% CI	0.19, 0.39	—	
Median	0.1	—	
(Q1:Q3)	0:0.22	—	

(*continued on next column*)

CDVA = corrected distance visual acuity; CI = confidence interval; Q1:Q3 = first quartile:third quartile

*Difference between patients examined and those who participated in questionnaire only

Correlation statistics (Spearman and partial) were used to analyze the change in the VF-14 total score from postoperatively to 15 years after surgery in relation to sex and age as a continuous variable.

The related-samples Wilcoxon signed-rank test was used to analyze the longitudinal change in CDVA postoperatively versus 15 years after surgery. Kaplan–Meier analysis was used to plot survival curves for the event Nd:YAG laser capsulotomy in relation to age at cataract surgery and sex. Curves were compared by use of the log-rank test. All tests were 2-sided, and *P* values less than 0.05 were considered statistically significant.

RESULTS

The study included 190 patients who had cataract surgery 15 years previously. In brief, 810 patients who had cataract surgery were included, and 228 (28% of the original cohort) of these patients were still alive 15 years after surgery. Thirty-eight patients (20%) did not participate in the follow-up; of these 16 (8%) had dementia and 22 (12%) could not be located. Of the 190 patients included in the 15-year follow-up, 168 (88%) also had a clinical eye examination in a standardized manner. The major reason for not participating with the examination was trouble/unwillingness to travel to the clinic either because of illness or a reluctance to travel a long distance.

The surgical technique described in Patients and Methods was used in all eyes except 2. A foldable Acrysof MA60BM IOL (Alcon) was implanted in 180 patients (95%) and a rigid poly(methyl methacrylate) IOL in 7 patients (4%).

Table 1 shows the demographic and clinical data of the 190 participants. At the 15-year follow-up, there were no significant differences in age, sex, or CDVA at any assessment between the patients examined (n = 168) and those who participated on the questionnaire only (n = 22). At the 15-year follow-up, the 134 women (71%) were significantly older at 81 years (66 years at surgery) than the 56 men (29%) at 75 years (60 years at surgery) ($P = .001$).

Longitudinal Changes in Corrected Distance Visual Acuity in Operated Eye

The median CDVA in the operated eye deteriorated from 20/20 postoperatively (0 logMAR) postoperatively to 20/25 (0.1 logMAR) 15 years after surgery ($P = .0001$, related-samples Wilcoxon signed-rank test). The worsening compared with postoperatively was less than 0.1 logMAR in 100 (60%) of 168 patients, and 18 (11%) of 168 patients had worse CDVA 15 years after surgery than preoperatively.

Figure 1 shows the overall mean decrease in CDVA over the 15-year period in relation to increasing age at cataract surgery for men and women. Women had a significantly more pronounced decline in CDVA over 15 years; however, after adjusting for age the association was no longer significant ($P = .48$, univariate ANOVA).

Changes in Subjective Visual Function from Postoperatively to 15 Years After Surgery

Figure 2 shows box-plot graphs of the distribution of the VF-14 total score preoperatively, postoperatively, and 5, 10, and 15 years after surgery for the 190 patients participating in the questionnaire.

Before surgery, the median VF-14 total score was 79.4 (mean 74.7; 95% confidence interval, [CI] 71.7–77.8) and increased to 100 postoperatively (mean 94.0; 95% CI, 92.2–95.8). Five years after surgery, the median score was 98.2 (mean 93.5; 95% CI, 91.5–95.5), almost similar to 10 years after surgery (98.1; mean 92.3; 95% CI, 89.9–94.7); 15 years after surgery the median score had declined slightly to 97.8 (mean 87.3; CI, 83.9–90.7).

Patients older at surgery had a more pronounced decline in VF-14 total score over 15 years ($r_S = 0.36$, $P < .001$). Adding sex to partial correlation statistics did not influence the results.

Table 2 shows the longitudinal change in the VF-14 total scores from postoperatively to 15 years after

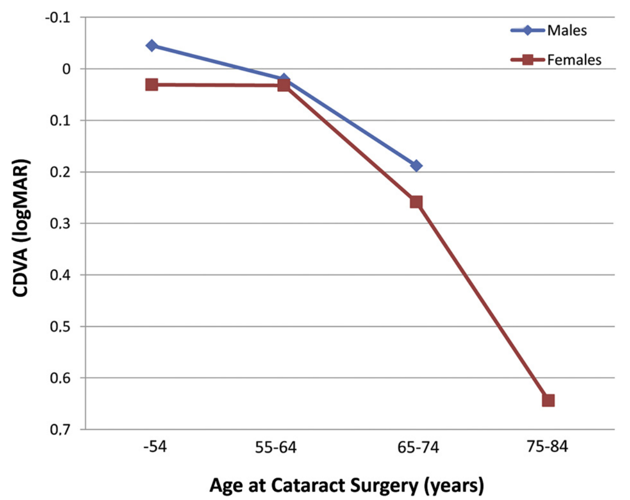

Figure 1. Mean change in logMAR CDVA from 1 to 2 months postoperatively to the 15-year follow-up in relation to age at cataract surgery for men and women (CDVA = corrected distance visual acuity).

surgery. Twenty-one (11%) of 190 patients had a worsening of more than 30 points; in the majority of these cases (13/21 [62%]), the most significant reason for the decline was age-related macular degeneration (AMD) followed by glaucoma (4/21 [19%]).

Fellow-Eye Surgery

Fifteen years after cataract surgery, 23 (18%) of 190 patients had not undergone surgery in the fellow eye. The majority of these patients (16/23 [70%]) had no cataract in the fellow eye, 6 (26%) of 23 patients had significant cataract of varying degree, and 1 patient (4%) had no indication for second-eye surgery because of no useful vision.

Neodymium:YAG Laser Capsulotomy

At 15 years, Nd:YAG laser posterior capsulotomy had been performed in 35% of the patients (65/188; 2 had posterior capsule rupture during surgery). Patients who were younger than 65 years at surgery had a significantly higher incidence (37/76 [49%]) than patients who were 65 years or older (28/112 [25%]) ($P = .002$, log-rank test) (survival curves in Figure 3). There was no statistically significant difference in Nd:YAG frequency between men and women ($P = .83$, log-rank test).

DISCUSSION

Function and quality of life are the outcomes of treatment that are most critical and applicable to the patient. Visual impairment causes increased direct and indirect costs at the individual level as well as increased expenses for the healthcare systems.[7] Loss

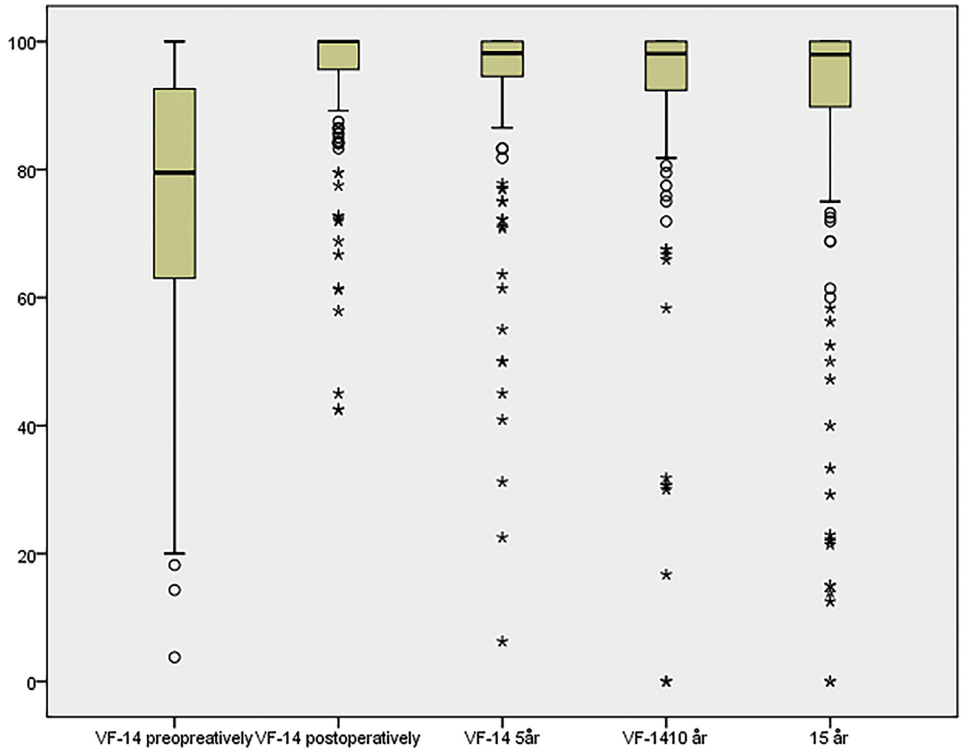

Figure 2. Box plots showing the longitudinal change in the mean VF-14 total score from preoperatively to 15 years after surgery (N = 190) (VF-14 = Visual Function-14 Questionnaire).

of visual acuity is associated with several adverse implications for health and well-being, such as diminished quality of life, decline in physical and mental functioning, work and academic underperformance, depression, reduced social interaction, increased frequency of falls and fractures, loss of driving ability, and loss of independence leading to institutionalization.[15–17]

Correction of visual impairment by cataract surgery has been associated with a 40% lower 15-year crude mortality rate also when known mortality risk factors were accounted for.[18] Therefore, there are clear benefits for interventions that prevent or delay vision loss, such as cataract surgery.

Table 2. Distribution of longitudinal change in the VF-14 total score from postoperatively to 15 years after surgery.

Category	No. of Patients (%)
No deterioration	103 (54)
0.1–10 points of decline	49 (26)
10.1–20 points of decline	12 (6)
20.1–30 points of decline	5 (3)
30.1–40 points of decline	6 (3)
More than 40 points of decline	15 (8)
	190 (100)

Longitudinal follow-up of this prospective, population-based sample made it possible to assess the long-term incidence of CDVA loss, patient-assessed outcomes, and Nd:YAG laser capsulotomy after phacoemulsification surgery. To the author's knowledge, no other population-based studies have examined and reported changes in visual functional outcomes after cataract surgery over a 15-year period.

The outcomes are similar to the 10-year results from this cohort.[8] Loss of median CDVA from 10 to 15 years after surgery was 3 letters. From postoperatively to 15 years after surgery, the median CDVA loss was 10 letters, and the VF-14 total score declined slightly from 100 to 97.8, which mainly can be explained by aging of the cohort as the patients were 15 years older. Compared with 10 years after surgery, there was no statistically significant increase in the percentage of patients with worse visual acuity 15 years after surgery compared with preoperatively (9% versus 11%) ($P = .55$, χ^2 test).[8] From public health and health-economic points of view, these long-term results must be considered excellent. These results justify resources and an expansion of eye healthcare provision to the older sector of the population.

Age-related macular degeneration remained the most important cause of declining visual acuity and reduced subjective visual function 15 and 10 years after cataract surgery.[8]

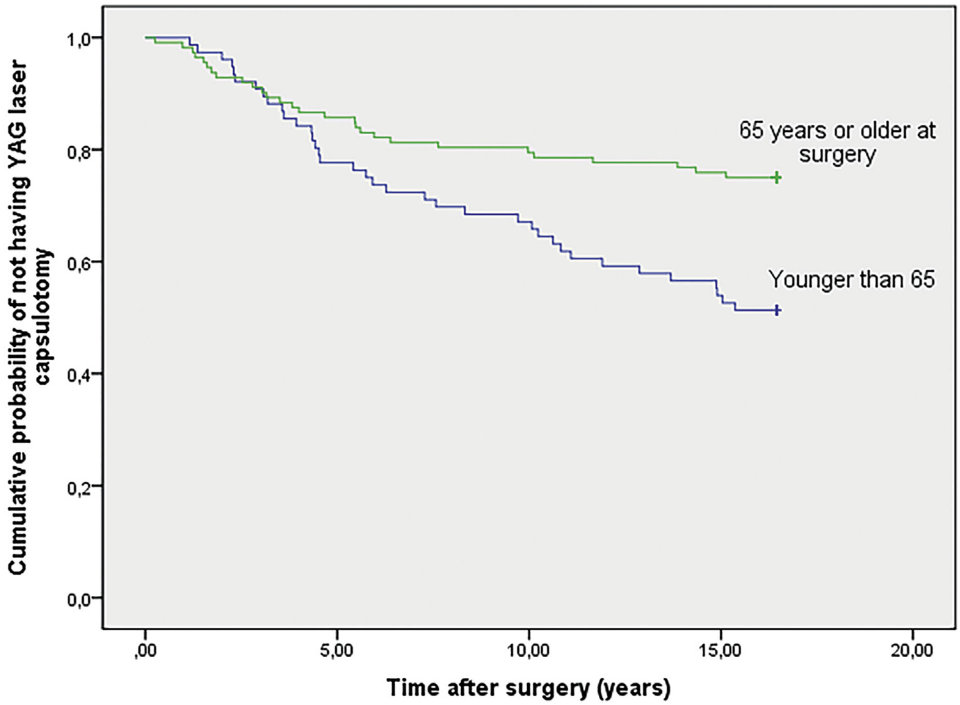

Figure 3. Kaplan–Meier plot showing the cumulative probability over 15 years of not having an Nd:YAG laser capsulotomy (ND:YAG = neodymium:YAG).

There is an ongoing debate whether cataract surgery can promote AMD progression. Several studies support that the long-term risk of developing above all late AMD, but also early AMD, is higher in eyes with previous cataract surgery, independent of other risk factors.[19,20] Older age, preexisting early AMD lesions, and increasing time might increase the risk for progression to later stages of AMD after cataract surgery.[1,3]

On the other hand, there are reports that cannot confirm such observations.[21,22] In the present study, all study patients had significant cataracts with unacceptable visual function at surgery in 1997 to 1998. The present study was not designed to evaluate the issue of AMD, and further investigation is needed concerning this issue.

Disturbed motion perception, disturbed stereoacuity, and problems with anisometropia are reported disabilities perceived by patients with cataract in the fellow eye after first-eye surgery.[23] Numerous publications have shown that patients who had bilateral surgery had greater improvement in functional status and were significantly more satisfied with their visual function than patients having first-eye surgery. Second-eye surgery improves mobility and orientation and aids in avoiding falls.[23,24] In most developed countries, there has been a shift to earlier and more frequent second-eye surgery, which now accounts for 35% to 40%.[5] Bilateral cataract surgery is regarded as cost-effective.[25] This can explain why more than 80% of the patients in the present study were operated on in both eyes.

Thirty-five percent of all patients had an Nd:YAG laser capsulotomy 15 years after surgery, with a higher incidence in younger patients. Results in a recent 12-year prospective study using the same IOL (Acrysof MA60BM) show that 50% of the patients had an Nd: YAG laser capsulotomy 9 years after surgery, which is lower than in the present study.[26] This might be explained by younger patients in the 12-year study in which only 30 patients were studied. The sharp-edged hydrophobic acrylic IOL used in most patients in the present study has been reported to have low rates of posterior capsule opacification at various time intervals.[26,27]

The major strengths of this longitudinal study include its prospective, population-based design with follow-up at 4 different timepoints spanning 15 years, with low refusal rates and a high participation rate at all examinations. Selective unavailability to follow-up is an important bias in prospective cohort studies. Patient dementia and inability to locate the patient were the only reasons for not participating, at least on the questionnaire. Eighty percent of the survivors were included in the study, which took into account that the time span of 15 years must be acceptable. This provides opportunities to generalize the results.

All surgical procedures were performed at a single institution, and only 4 surgeons were involved. There were no variations in surgical technique that would have influenced the results.

A common problem with follow-up studies extending over a longer period of time is that changes in technology make results impossible to compare with newer surgical techniques. This is probably not a major problem of the present study because foldable hydrophobic IOLs were used in 1997. The only difference compared with cataract surgery now is that the incision size has decreased from 3.2 mm to 2.2 mm and that IOLs are implanted with the use of injectors and not a forceps as in 1997.

The same questionnaire (VF-14) was used at all follow-up visits to enable direct comparison. This questionnaire is highly responsive, which supports its usefulness for assessing change in visual function after cataract surgery.[12]

This report has a number of limitations, including the relatively small number of subjects remaining 15 years after surgery. This is inevitable because the mean age at surgery in 1997 to 1998 was approximately 75 years[9] and the main reason for dropout was death.

The use of patient-reported outcomes (questionnaires) assessing visual disability or activity limitations, as an additional measure of surgical outcome, has increased.[28]

In the past decade, there has been a paradigm shift in patient-reported measures. New questionnaires have been developed, and several old questionnaires such as the VF-14 have been revalidated through the use of Rasch analysis–based techniques. Although the VF-14 questionnaire has been an appropriate instrument for capturing clinically important changes after cataract surgery, Rasch analysis revealed weakness in questionnaire construction; for example, disordered thresholds, ceiling effect, and suboptimum targeting.[12,28]

In the present study, at each examination, summary scores of the original VF-14 questionnaire were used to make it possible to compare scores from the early version of the VF-14. The problems caused by the old scoring of the VF-14 were reduced by the longitudinal design of the study because the patients were compared with themselves. The ceiling effect is also less pronounced after 5 years or more postoperatively. Therefore, the Rasch analysis–based revision of the VF-14 was not used in the present study.

This report extends previous findings of a good long-term outcome of cataract surgery.[8] Most patients had good to excellent subjective visual function and retained visual acuity in the surgical eye 15 years after cataract surgery with modest rates of Nd:YAG capsulotomy. Patients with significant cataracts can be advised that in most cases, the visual prognosis is favorable for as long as 15 years after cataract surgery.

WHAT WAS KNOWN

- Long-term visual results up to 10 years after cataract surgery have shown satisfactory outcomes regarding visual acuity and VF-14 scores.
- Little is known about population-based estimates of Nd:YAG frequency 15 years after cataract surgery.

WHAT THIS PAPER ADDS

- This prospective population-based study found a preserved long-term visual rehabilitation in the majority of the patients 15 years after cataract surgery.
- Neodymium:YAG laser capsulotomy had been performed in 35% of the total patient group, which might be regarded as a low figure, especially because most patients were younger than 70 years at surgery.

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First author:
Eva Mönestam, MD, PhD

Department of Clinical Sciences/ Ophthalmology, Faculty of Medicine, Umeå University, Umeå, Sweden