Long-term outcome after cataract surgery – a longitudinal study.

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To Oskar, Amanda, and Julia!
ABSTRACT

Background

Cataract surgery is the most common surgical procedure carried out in the developed world and surgery volumes have increased considerably during the last decades. Various aspects of the surgical procedure, including surgical incision size and intraocular lens materials, have changed substantially, improving the safety and the quality of the outcome. Previous research has primarily focused on the visual function results with a short follow-up time. Long-term population-based studies, exceeding a few years, presenting visual functional results postoperatively, have not been published.

Aims

To determine the effects of cataract surgery on subjectively experienced visual function and visual acuity in a defined population, and compare the results between sub-groups, on a long-term basis.

Methods

In this prospective, population-based investigation, all patients with presenile and senile cataract (n=810), operated on during a one-year period (1997-98), at Umeå University Hospital were included. The frequency of cataract surgery at that time, was 5.2 per 1000 population studied. Visual acuity was tested and an eye examination was performed before surgery, 4-8 weeks postoperatively, and five and ten years after surgery. Subjective visual function was assessed using self-administered questionnaires (VF-14) at all occasions. Statistical evaluations comprised analyses of variance, Mann-Whitney
U-test, chi-square test, multiple linear regression, a life-table calculation, and Cox’s proportional hazard model.

**Results**

Five years after cataract surgery, subjective and objective visual function remained stable in most patients. The most frequent cause of deterioration of visual acuity and decrease in VF-14 scores was age-related macular degeneration (ARMD).

Two thirds of the patients in the cohort were women. They were significantly older than the men and more often operated on both eyes. After adjustment for age and visual acuity, women cataract surgery patients assessed their visual function worse than men both before surgery and 4 months postoperatively. Five years after surgery these differences were no longer significant.

At baseline, 13% of the patients were diabetics. At the five-year follow-up, subjective and objective visual function remained stable in most surviving diabetics, and the longitudinal visual function was not significantly worse compared with the non-diabetics.

Ten years after surgery, 28% had received treatment for posterior capsular opacification (PCO). A significantly larger proportion of patients less than 65 years at surgery (37%) compared with those 65 years or older (20%) had been treated.

**Conclusions**

Most patients sustain their level of visual acuity and visual function also five and ten years after cataract surgery. Ocular co-morbidity, such as ARMD, is the major cause of longitudinally reduced visual
function. Patients suffering from diabetes did not have a significantly worse visual function after five years. A surprisingly large proportion of patients had received treatment for PCO after ten years.

**Key words**

Cataract, cataract surgery outcome, longitudinal study, subjective visual acuity.
SVENSK SAMMANFATTNING

Bakgrund

Kataraktkirurgi (gråstarroperation) är den vanligaste operationen i västvärlden och operationsvolymerna har ökat markant under de senaste decennierna. Olika aspekter av kirurgin, som t.ex. storleken på operationssnittet och materialet i de nya linserna, har förändrats väsentligt. Det har medfört ökad kvalité och bättre resultat. Tidigare forskning har framförallt bekrivit operationsresultaten med kort uppföljningstid. Långtidsstudier beträffande synfunktionen som sträcker sig längre än några år efter operationen har inte tidigare publicerats.

Syfte

Att fastställa hur kataraktkirurgi påverkar subjektiv synfunktion och synskärpa i en befolkning under ett längre tidsperspektiv. Att jämföra resultaten mellan olika grupper.

Metod

I denna prospektiva, populationsbaserade undersökning inkluderades alla patienter med senil och presenil katarakt (n=810), som opererades under ett års tid (1997-98) vid ögonkliniken, Umeå Universitetssjukhus. Vid tiden för studien var frekvensen kataraktoperationer 5.2 per 1000 invånare. Synskärpan kontrollerades och en ögonundersökning genomfördes före operationen, 4-8 veckor efter operationen, samt 5 och 10 år senare. Den subjektiva synfunktionen kontrollerades med hjälp av en enkät, den s.k. VF-14. Olika metoder som, variansanalys, Mann-Whitney U-
test, chi-square test, multipel linjär regression, samt Cox-analys

tillämpades för de statistiska beräkningarna.

**Resultat**

Både subjektiv (resultat från enkät) och objektiv (synskärpa)

synfunktion var stabil bland de flesta patienter. Den vanligaste

orsaken till försämring av synfunktionen var åldersförändringar i gula

fläcken (makuladegeneration).

Två tredjedelar av studiens deltagare var kvinnor. De var signifikant

äldre än männen och oftare opererade på båda ögonen. Efter

justering för ålder och synskärpa, skattade kvinnorna sin synfunktion

sämre än männen både före operationen och efter 4 månader. Fem år

senare var skillnaderna inte längre signifikanta.

Vid studiens början var 13% av deltagarna diabetiker. Vid 5-

årskontrollen var både den subjektiva och de objektiva synfunktionen

stabil hos de flesta diabetiker som fortfarande var i livet.

Förändringen i synskärpa från postoperativt till fem år efter

operationen var inte signifikant sämre än den som noterades hos

icke-diabetiker.

Tio år efter operationen hade 28% behandlats med laser pga

efterstarr. En signifikant större andel patienter som var yngre än 65

år vid tiden för operation (37%) jämfört med de som var 65 år eller

äldre vid operationstillfället (20%) hade behandlats.
Konklusion


Nyckelord

Gråstarr, resultat efter gråstarrkirurgi, långtidsstudier, subjektiv synfunktion.
**ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ARMD</td>
<td>Age-related macular degeneration</td>
</tr>
<tr>
<td>BCVA</td>
<td>Best corrected visual acuity</td>
</tr>
<tr>
<td>DR</td>
<td>Diabetic retinopathy</td>
</tr>
<tr>
<td>ECCE</td>
<td>Extra capsular cataract extraction</td>
</tr>
<tr>
<td>ETDRS</td>
<td>Early Treatment Diabetic Retinopathy Study</td>
</tr>
<tr>
<td>ICCE</td>
<td>Intra-capsular cataract extraction</td>
</tr>
<tr>
<td>IOL</td>
<td>Intraocular lens</td>
</tr>
<tr>
<td>logMAR</td>
<td>Logarithm of the minimum angle of resolution</td>
</tr>
<tr>
<td>Nd:YAG</td>
<td>Neodymium, yttrium, aluminium, and garnet</td>
</tr>
<tr>
<td>PCO</td>
<td>Posterior capsular opacification</td>
</tr>
<tr>
<td>PMMA</td>
<td>Poly (methyl metacrylate)</td>
</tr>
<tr>
<td>PVA</td>
<td>Presenting visual acuity</td>
</tr>
<tr>
<td>SD</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>VA</td>
<td>Visual acuity</td>
</tr>
<tr>
<td>VF-14</td>
<td>Visual Function Questionnaire (with 14 questions)</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>QOL</td>
<td>Quality of Life</td>
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ORIGINAL PAPERS

This thesis is based on the following original papers, which will be referred to in the text by their Roman numerals.


III Lundqvist B., Mönestam E. Longitudinal changes in subjective and objective visual function in diabetics 5 years after cataract surgery. Submitted.


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INTRODUCTION

Cataract, definition and anatomy

Cataract is defined as an opacification of the crystalline lens leading to visual impairment, usually manifested in ageing people. There is no known protective agent that can delay the onset or progression of cataract. The disorder cannot be cured by laser or drugs, and in the past it led to blindness. Today, only one treatment is known, to surgically remove the lens and replace it by an intraocular plastic lens.¹

The crystalline lens is one of the few structures of the body with continuous growth during lifetime.² The structure is transparent, biconvex, and avascular, and situated in the anterior part of the eye, behind the iris.

Figure 1. The lens and the cornea (From www.doctor-hill.com. Reproduced with permission from East Valley Ophthalmology).
The lens plays a major role in the optical system of the eye and is responsible for $1/3$ of the refractive power, while the remaining $2/3$ are provided by the cornea. At birth, the diameter of the lens measures about $6.5\, \text{mm}$ at the equator, and increases in size to approximately $9\, \text{mm}$ in the adult eye. The lens is derived from ectodermal tissue and contains epithelial cells that produce lens fibres throughout life-time. With increasing age, these lenticular fibres become more compact and thicker, and gradually there is an accumulation of yellow-brown pigment in the fibres. These changes reduce light transmission, and when there is a loss of optical clarity, the lens is cataractous\(^3\). Since cataract most commonly appear in elderly people, it is called “senile cataract”. However, if cataract develops before the age of 60, it can be defined as a presenile cataract.

The lens fibres are surrounded by a capsule, and zonular fibres attached to the ciliary body support the lens.

**Figure 2. Anatomy of the eye** (From www.doctor-hill.com. Reproduced with permission from East Valley Ophthalmology).
Cataract is not always due to ageing. Other causes include congenital disorders, metabolic conditions, and various forms of trauma, e.g. direct penetration and contusion.\textsuperscript{2} Furthermore, cataract development is enhanced by environmental factors such as smoking,\textsuperscript{4} and ultraviolet radiation.\textsuperscript{5} Systemic and inhaled corticosteroids have been associated with posterior subcapsular cataract, and higher doses and longer duration increase the risk for cataract.\textsuperscript{6} In several epidemiological studies, diabetes has also been considered a risk factor for cataract.\textsuperscript{7-9} In experimental studies, cataract develops more frequently in mice lacking the enzyme superoxide dismutase.\textsuperscript{10,11} This enzyme protects against oxidative stress, which plays an important role in the development of cataract as well as macular degeneration.

There are three main types of age-related cataracts: nuclear, cortical, and posterior subcapsular.\textsuperscript{12}

- **Nuclear cataracts** tend to progress slowly, and they are usually bilateral. This type of cataract forms in the nucleus, in the center of the lens. Typically they cause greater impairment of distance vision because increased density of the lens nucleus causes a “myopic shift”, which also may enable presbyopic individuals to read without glasses.

- Opacification of the lens cortex can lead to **cortical cataract**, where the main symptoms can be glare, and monocular diplopia. The opacities are located in the cortical layer and initially develop in the lower portion of the lens. In early stages of cortical cataracts, water clefts and vacuoles can be
seen. In more advanced stages, wedge-shaped opacities progress circumferentially.

- **Posterior subcapsular** cataract is located in the posterior cortical layers of the lens. At slit-lamp examination, granular, sometimes glistening opacities are present in the posterior pole. This type of cataract is especially associated with the use of steroids, myopia, and diabetes. Patients with posterior subcapsular cataract often complain of glare and poor vision under bright lighting conditions. Near vision acuity tends to be more reduced than distance visual acuity.

**Figure 3. Nuclear, cortical, and subcapsular cataract**

All these three types of cataract lead to blurred vision at far and near, reduced contrast acuity and color perception. Cataract surgery is the only available treatment.

**History of cataract surgery**

The word cataract, “chatharacta”, derives from the Greek word meaning waterfall. Until the mid 1770s, it was thought that cataract
was formed by opaque material, flowing like a waterfall, in the eye. Sanskrit manuscripts from the 5th century B.C. describe a type of cataract surgery known as “couching” or “reclination”. In this technique, a needle was inserted into the eye, and the cataractous lens was displaced away from the pupil and pushed into the vitreous cavity. This displacement enabled the patient to see better.

**Figure 4. Couching** (From www.mrcophth.com).

The complication rate with this kind of surgery was extremely high, and the visual results were, at that time, very limited without spectacles. This method would, however, allow patients with mature cataracts to regain a limited degree of vision which was better than cataract blindness.

A new method for removing the cataract was introduced by Jacques Daviel in Paris in 1748. By using pressure of his thumb, he removed the entire lens intact through an incision.
It was not until the 1840s that general anesthesia was introduced for surgical procedures, and in 1884 cocaine drops were developed for topical anesthesia.\textsuperscript{13}

In 1949, after studying shrapnel wounds in the eyes of soldiers during World War II, the British ophthalmologist Harold Ridley was the first surgeon to introduce the intraocular lens (IOL), a permanent plastic lens implanted inside the eye to replace the crystalline lens.\textsuperscript{16} Over the next years many doctors disagreed with replacing the natural lens with a foreign, artificial lens. It was not until the end of the 1970s,
that replacement of the opaque lens by a plastic intraocular lens became the technique of choice when performing cataract surgery.

In 1957, the Spanish ophthalmologist, Barraquer, used alpha-chymotrypsin to dissolve the zonular threads to simplify removal of the lens.\textsuperscript{17} Cryosurgery was introduced in 1961 by the Polish surgeon Krwawicz.\textsuperscript{18} The lens was removed by using a tiny probe that could attach by freezing a small area on the surface of the cataract.

In the late 1960s, Charles Kelman from New York developed a technique of emulsifying the lens contents within the capsular bag, using ultrasonic vibrations and aspiration of the emulsified cataract.\textsuperscript{19} The ultrasonic technique is still the treatment of choice for most cataract surgery in the western world.

**Surgical techniques and indications**

There are two basic types of cataract surgery - intracapsular and extracapsular cataract extraction. *Intracapsular cataract extraction (ICCE)* is the removal of the whole lens and its intact capsule.\textsuperscript{20} The removed lens is replaced either by the insertion of an intraocular lens in the anterior chamber of the eye, or by the use of aphakic glasses. Due to postoperative complications, and poorer results, this technique is no longer in use in the developed world. It is still performed in the developing world, however, because it is less costly and can be performed by trained surgeons in a couple of minutes. Furthermore, with this technique, the secondary problem of posterior capsular opacification is avoided.\textsuperscript{21}
Extracapsular cataract extraction (ECCE) was introduced in the early 1980s. The posterior lens capsule is retained in the eye, and the lens contents are removed through a relatively large incision (9mm). A posterior chamber lens can then be placed in the capsular bag.\textsuperscript{22,23}

The modern extracapsular cataract extraction technique, use phacoemulsification, in which ultrasonic energy breaks the nucleus down into small pieces that can be aspirated. This can be done through a small incision of about 2mm. The advantages with these small incisions are faster visual rehabilitation and low induced astigmatism. On the other hand, it requires an expensive phacoemulsification machine, and trained surgeons.\textsuperscript{24}

In Sweden, during the 1990s, an increasing proportion of cataract surgery was performed using phacoemulsification. When the study this thesis is based on started in 1997, 89\% of all cataract surgery was performed by phacoemulsification.\textsuperscript{25}

In phaco-emulsification the following steps are performed:

1. A small incision and a side port are made, usually at the limbus of the cornea.
2. Anesthesia is injected in the anterior chamber. (When this study started in 1997-98, topical anesthesia was used in most cases, and anesthesia was injected into the anterior chamber when necessary).
3. A viscoelastic substance is injected into the anterior chamber to maintain the chamber space and protect the endothelium of the cornea during the rest of the procedure.
4. A round shaped tear is made in the central part of the anterior capsule of the lens. This allows access to the contents of the lens.

5. Hydrodissection of the lens by fluid in order to separate the lens from the lens capsule, and the lens nucleus from the cortical layer.

6. The lens is removed by the phacoemulsification handpiece.

7. Once the capsule bag is empty, further viscoelastic substance is injected, to maintain the space while the foldable replacement lens implant is positioned into the capsular bag (in-the-bag IOL implantation).

8. Injection of an antibiotic substance into the anterior chamber to reduce the risk of endophthalmitis.

**Figure 6. Phacoemulsification.**

(Reproduced with permission from Alcon).
Indications for cataract surgery

In the past, when cataract surgery was performed by removing the entire lens and leaving the patient aphakic (ICCE), it was necessary that the cataract was dense enough to be able to remove it in a single entire piece. As the surgical techniques have become safer and the visual results have improved,26 “maturity of the cataract is no longer a consideration, and surgery is performed at a much earlier stage when phacoemulsification is used. It is beneficial, in terms of surgical complications, to remove the cataract before it becomes too advanced.27

It is widely accepted, that visual acuity alone is an inadequate measure of the need for cataract surgery.28 Visual acuity measures only the smallest detail we can see, but in general, it does not represent the quality of vision. Instead, any problem with self assessed visual function is regarded as the single most important variable when cataract surgery is recommended.29

There is no distinct rule regarding when to perform cataract extraction. The indication varies, depending on the patients’ age and visual functional demands.21 At present, the basic indication for cataract surgery is a significant cataract, which reduces visual function, making activities of daily living more difficult. Surgery should be considered when the benefits from removal of symptoms outweigh the small risks caused by modern surgery.2
Epidemiology and public demands

Cataract remains the leading cause of blindness globally, except in the most developed countries. The World Health Organization (WHO), estimated that in 2002, about 45 million people worldwide were blind, half of them because of cataract. Due to the changing demographic structure of several populations, with increasing proportion of elderly in society, and longer life expectancy also in the developing world, the number of people blind from cataract is expected to rise. WHO projections indicate that, in 2020, as many as 40 million people will be blind because of cataract.

The prevalence of cataract has been investigated in several epidemiological studies. One of the most cited is the Framingham eye study, in which 2675 of the inhabitants in the town Framingham, Massachusetts, USA, were investigated for glaucoma, diabetic retinopathy, age-related macular degeneration, and cataract. Lens opacities were found in 80% of those over the age of 75, and in 46%, there was a decrease in vision to 20/30 or worse as well.

In the Beaver Dam Study from 1988-90, Klein et al. examined 4926 participants with slit lamp and retro-illumination lens photographs to estimate the presence of cataract. The prevalence of cataract formation in combination with a decrease in vision to 20/30 or worse was found in 25% of women and in 13% of men older than 75 years.

In a Swedish cross-sectional population-based study from 2001, 5000 inhabitants between 70-84 years of age were examined. When using a definition of cataract based on morphologic changes only, regardless of the visual acuity level, the prevalence of cataract was 24% for
women and 14% for men in the entire cohort. If any previous cataract surgery was included, the total prevalence increased to 42% for women, and 27% for men. The difference between men and women was significant in all age groups, except for the youngest (70-74). Also, the VA level was lower in women than in men.

The modern life-style with pronounced need for excellent vision, has increased the demand for cataract surgery. In combination with the improved postoperative surgical results, as well as the increased life expectancy, the number of cataract extractions performed has risen dramatically over the last thirty years. In 1980, about 7000 cataract extractions were performed in Sweden. In 2003, this figure had increased to just above 80000, making up to more than a 10-fold increase. In the last few years, the rate of surgery has decreased, but still there were almost 74000 eyes operated on in 2008. In the admitting area of the present study, this corresponds to a surgical rate of 7.8 per 1000 inhabitants, compared with 5.2 per 1000 inhabitants when this study started in 1997. The increase in frequency of cataract surgery is equal for both sexes and all age groups.
Figure 7. The frequency of cataract surgery in Sweden between 1980 and 2008.

(From the Swedish National Cataract Register, 2008. Reproduced with permission from Mats Lundström).

Second-eye surgery has increased as well, from 29% in 1992 to 40% in 2008. Having cataract extraction on both eyes if, of course, there is a vision-disturbing cataract in the fellow eye, results in significantly better visual functional outcome than first eye surgery alone.42,43 Improvement and satisfaction with vision is most frequently found in patients going through surgery of both eyes with a short interval between procedures.44,45 Even if there is a substantial increase in visual acuity following first eye surgery, both stereopsis and patient-reported visual function will improve after surgery of the fellow eye.46
It has previously been well documented that the cataract surgery rate in Sweden is significantly higher in women than in men, except for the younger age groups (<65), and for the very old (>90). In 2008, 61% of all the patients having cataract surgery were women. This is in part explained by women living longer than men and being more numerous in the older ages. Age-related lens opacities are also more common in women than in men, regardless of age.

**Outcome studies**

With increasing cataract surgery volumes in most parts of the world, the importance of well conducted follow-ups have been emphasized. There are several studies on cataract surgery outcome, presenting complications and the benefits concerning final VA. However, traditional clinical measures of vision, such as Snellen visual acuity and decimal acuity, are imperfect when calculating the need for or outcome of cataract surgery. The most important outcome measure is the patients' self assessed visual function. Different generic and disease-specific health status instruments have been developed to evaluate patients' outcomes. A generic health status questionnaire intends to describe the quality of life, defined by WHO as “an individuals’ perception of their position in life in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards and concerns”. Some of the more frequently used generic measures in medical outcome studies are the MOSSF-36 (Medical Outcome Study Short Form-
36), the SIP (sickness impact profile), the HRQoL (Health Related Quality of Life).

When presenting the outcome after cataract surgery, disease-specific measures are more adequate in describing visual functional change. When this study started, in 1997, the VF-14 questionnaire had been introduced a few years earlier. It was found to be a reliable and valid measure of functional impairment caused by cataract. Also, it provided more information than visual acuity or general health status measures could reveal. After the VF-14 questionnaire was introduced in 1994, several other well-validated instruments, such as the Catquest, developed for use in the Swedish National Cataract Register, have been presented. Other disease-specific instruments that measure cataract related quality of vision are the ADVS (Activities of Daily Vision Scale), and the 12-item Cataract TyPE Spec. Today, there are also several quality of life questionnaires measuring the contentment of patients suffering from other ocular diseases such as glaucoma and optic neuritis.

In terms of health economics, cataract surgery is described as a relatively cost-effective intervention. A cost-benefit analysis compares the costs of a specific surgery, against the money saved, e.g. what does it cost if someone can not work because of vision-impaired cataract or what is the cost for society if an elderly person needs home assistance because of hip arthritis. However, in these analyses quality of life issues are ignored.

The cost-effectiveness analysis describes the quality of life issues as well. DALY (disability-adjusted life years), or vision-years in ophthalmology, intends to specify the life-years gained or saved by a
specific intervention. A cost-utility analysis takes all these matters into account, and therefore enables a comparison between different medical interventions that include surgery, i.e. epileptic surgery, hip arthroplasty, knee arthroplasty, carpal tunnel surgery, and defibrillator implantation. The cost-utility of cataract surgery can vary significantly depending on the duration of benefit, the life expectancy of the patient, and the impairment of visual acuity at the time of surgery. In a meta-analysis, including 12000 cataract surgery eyes from different countries, cataract surgery proved to be comparable in terms of cost-effectiveness to hip arthroplasty, and in general more cost-effective than both knee arthroplasty, and defibrillator implantation. One of the aims of the present study was to evaluate and describe the duration of the improvement of visual function after a cataract extraction.

**Gender in medicine**

During the past decades, there have been several reports of gender biases in clinical research, and to prevent this, a gender perspective has been requested. Gender is a wider concept than sex, and includes the social, cultural, and symbolic conception of men and women in society. There are two main types of models described in the scientific literature, explaining differences in health between men and women; the biological/generic models, which emphasize sex differences in biological makeup in terms of genes, hormones and physiology, and the socio-cultural models, which focus on gender
differences in health-related behavior and on life circumstances such as work and family.\textsuperscript{76}

Previous studies in ophthalmological research have reported sex-related differences in incidence and prevalence of several disorders, such as age-related macular degeneration,\textsuperscript{77} keratoconus,\textsuperscript{78} and dry eyes.\textsuperscript{79} It is also well known that cataract extractions are performed more frequently in women compared to men, and women is the predominant group among patients undergoing cataract surgery by a 2:1 ratio.\textsuperscript{80} This difference remains when adjusting for the fact that women live longer. The predominance of women seems to be more pronounced in the higher age groups.\textsuperscript{81}

Several explanations have been suggested. One reason could be a higher prevalence of cataract in women.\textsuperscript{82} Another reason could be that men tend to accept a larger visual loss before they request surgery. Diverging results have been reported concerning gender-related differences in visual acuity before cataract surgery. Ninn-Pedersen et al.\textsuperscript{82} as well as Morgan et al.\textsuperscript{83} reported that men tend to accept a larger visual loss than women before they request surgery. This is in conflict with the results of Carlsson & Sjöstrand\textsuperscript{47} who reported no difference between sexes in pre-operative visual acuity in the better-seeing eye. They explained the higher utilization of cataract surgery in women simply with a higher prevalence of cataract. Another study presenting data on differences in pre-operative visual acuity reported women with a moderately impaired visual acuity in the best eye to have cataract surgery to a much higher degree than men with the same pre-operative visual acuity loss.\textsuperscript{48} The question was raised whether women and men request cataract surgery at
different stages of visual impairment. Regarding the subjective visual function, Mönestam et al reported in 1998, that women experience more functional impairment than men at the same visual acuity level.\textsuperscript{84}

Lundström et al,\textsuperscript{48} discussed three possible hypotheses responsible for the higher utilization of cataract surgery in women:

1. The prevalence of cataract is higher in women compared to men in certain age groups.

2. Women request cataract surgery more often than men because their everyday life is more disturbed by a cataract.

3. The need for cataract surgery is equal in women and men but women are favored by the health care system.

A plausible explanation to the third hypothesis could be that women, compared with men, because of a higher frequency of other medical problems, more often have contact with the health care system. They have more opportunities to mention visual problems, and ask for a referral to an ophthalmologist. Another explanation could be that maybe men are less verbal than women and less prone to express visual functional problems.\textsuperscript{48}

The role of hormones such as estrogen in cataract formation is contradictory.\textsuperscript{85,86} Whether the excess risk of women developing cataract is related to different hormonal effects or differences in metabolic or noxious effects due to life style is not known. In their report from the Beaver Dam Eye Study, Klein et al. presented results showing that current use of postmenopausal estrogens was associated
with a reduced risk for nuclear sclerosis. Older age at menopause was associated with a decreased risk for cortical cataracts. This suggests that estrogen exposure has a modest protective effect on the lens. Similarly, in the Framingham Eye Study, a longer duration of postmenopausal estrogen therapy was inversely associated with nuclear cataract, but no association was found for cortical cataract.88

On the other hand, the Blue Mountain Eye study from Australia reported no association with age at menopause, number of children, or use of the oral contraceptive pill.89 However, low age at menarche was associated with increased prevalence of all types of cataract.

In a recently published Swedish cohort study investigating risk factors for cataract in women, the results indicate an increased risk for the development of lens opacities in postmenopausal women using hormone replacement therapy for long period of time.90

Awareness of the differences between men and women in prevalence of cataract is important in the management of patients seeking medical care for vision-related problems.

**Diabetic retinopathy, diabetes and cataract**

Diabetes affects more than 6% of the overall population in developed countries,91 and the prevalence is rising throughout the world.92 According to WHO projections, the number of people suffering from the disease will be close to 370 million by 2030.92 With increasing rates of diabetes over the past decades,93 complications like diabetic retinopathy (DR) will probably become more common.
Diabetes is characterized by a persistently high blood glucose level, either from low insulin production in the pancreas or from a resistance to insulin in the body tissues. Eye complications from diabetes include, for example, DR and cataract. Diabetic patients develop cataracts more frequently than non-diabetic patients and at a younger age.

One of the most common risk factors for cataract in the developed world is diabetes. There is a three- to fourfold increased prevalence of cataract in diabetic patients under the age of 65 years, and a twofold increased prevalence in diabetics over 65.

Cataract in diabetics is significant for a number of reasons. It impairs the recognition of sight-threatening DR and there is a risk that any present DR can deteriorate. Particularly diabetic maculopathy can be exacerbated by cataract surgery.

Previous guidelines did not recommend cataract surgery in diabetic patients until vision was severely deteriorated, due to the increased risk for postoperative complications, e.g. inflammatory reactive uveitis and progression of retinopathy. However, this belief is outdated as modern cataract surgery using small incision phacoemulsification is less disruptive than intracapsular and extracapsular cataract extraction. Several studies have reported fewer postoperative complications and generally more encouraging result.

The best time to perform cataract surgery in diabetics is simply when the patient is symptomatic and before the view of the retinal fundus becomes significantly impaired. Preferably this would be when there
is no DR present, as it has been shown that the severity of retinopathy at the time of the cataract extraction is the most important predictor of poor visual acuity.\textsuperscript{106} If any retinopathy is present it should be optimally treated prior to surgery.\textsuperscript{107}

There are several previous studies describing diabetic retinopathy progression after cataract surgery. However, few reports concern visual function, and in these studies only short-term data are presented.\textsuperscript{97,99}

**Posterior capsular opacification (PCO)**

Posterior capsular opacification (PCO) can be suspected if the visual acuity declines and visual disturbances such as halos, impaired contrast sensitivity, and monocular diplopia occur after cataract surgery.\textsuperscript{108,109} Even if there is polishing of the anterior and posterior capsule at the time of cataract surgery, some lens fibres are retained in the lens capsule periphery.\textsuperscript{110} Slowly, over time, residual lens epithelial cells can proliferate and migrate into the visual axis.\textsuperscript{111} The capsule can become so hazy and cloudy it may seem as if the cataract has returned (after-cataract). However, the cataract can never reoccur, but a secondary membrane with light scattering migrating cells may appear.

In clinical practice, PCO is evaluated through slit-lamp examination. Different scientific methods have been developed for evaluating the amount of PCO. The EPCO (Evaluation of Posterior Capsule Opacification) image analysis system uses retro-illumination color
photographs to score PCO. The individual PCO score is calculated by multiplying the density of the opacification, graded from 0 to 4 (0=None, 1=minimal 2=mild, 3=moderate, 4=severe), by the area of the posterior optic involved.\textsuperscript{112,113} Another method for measurement of PCO is the Anterior Eye Segment Analysis System (EAS-1000; Nidek, Japan) using the Scheimpflug photography system. The central 3-mm portion of the posterior capsule is quantitated by means of area densitometry. Scheimpflug slit images are taken at 4 different meridians after dilatation of the pupil and analysed with a computer program.\textsuperscript{114,115}

When the PCO becomes clinically significant, in terms of reduced vision, the patient may demand a Nd:YAG laser capsulotomy. The initials are an acronym for neodymium, yttrium, aluminum, and garnet, which are the materials components utilized to allow the laser to function properly, as a knife, and open the membrane. The laser procedure is fairly easy but can be associated with complications such as cystoid macular edema,\textsuperscript{116,117} retinal attachment,\textsuperscript{118-120} intraocular pressure elevation,\textsuperscript{117} and damage to the intraocular lens.\textsuperscript{121-124}

The incidence of PCO can be influenced by:

- patient-related factors (age, systemic or ocular diseases)
- surgery-related factors (capsulorhexis size, cortical clean-up, in-the-bag IOL fixation, anterior capsule over-lap)
- IOL design related factors\textsuperscript{125-131}

In pediatric cataract surgery, posterior capsular opacification formation is a well-known complication, occurring in 40-100\% of cases
if the posterior capsule is left intact.\textsuperscript{132-134} To preserve a clear visual axis, a primary posterior capsulorhexis can be performed.\textsuperscript{135} After the cataractous lens is removed, viscoelastic is placed in the capsular bag to stabilize it. With the capsulorhexis forceps, a round opening of the posterior capsule can then be completed.\textsuperscript{136}

To prevent PCO formation also in adults, some surgeons perform a posterior optic buttonholing (POBH) through a primary posterior capsulohexis.\textsuperscript{137} In this procedure, a standard anterior capsulorhexis and phacoemulsification is completed. A posterior capsulorhexis is then performed and the lens is implanted with the haptics in the capsular bag and the optic behind the posterior capsule. This method is sometimes called the “sandwich method”, since the posterior capsule blocks optic contact and thus fibrosis of the anterior capsule. Posterior optic buttonholing prevents after-cataract independent of optic edge design. Favorable results have been published,\textsuperscript{137} however, the surgical technique is demanding. Longer follow-up to determine whether this method is an alternative to standard in-the-bag IOL implantation is not yet available.

Remnants of the lens epithelium increase the risk for PCO. Therefore, it is of importance to perform a thorough cortical clean-up at surgery. Furthermore, the size of the capsulorhexis should be slightly smaller than the optic to enable the anterior capsule rim to cover the IOL.

PCO is one of the major problems following cataract extraction, and some studies indicate a higher rate after cataract surgery in diabetics.\textsuperscript{138,139} Other studies, on the contrary, have failed to show any differences in the PCO rates between diabetics and non-diabetics.\textsuperscript{112,140} It has been proposed that inflammatory mediators
resulting from the breakdown of blood-aqueous barrier after surgery may contribute to the development of PCO. In all patients, it is important to maintain visual acuity after cataract surgery. In diabetics, it is also valuable to keep the posterior capsule clear to make retinopathy screening, retinal photocoagulation, and any future retinal surgery possible.

Following cataract extraction, implantation of an IOL decreases the incidence of PCO. In order to reduce the risk for PCO as well as retinal detachment, IOL implantation in highly myopic patients should be performed after cataract extraction, even though it might not be necessary for refractive reasons.

In the 1980s, when IOLs were first implanted, the material of choice was PMMA (poly methyl metacrylate). The frequency of posterior capsulotomies after implanting these lenses was as high as 50% in several studies. More modern IOL materials, such as the silicone lenses, and the hydrophobic acrylate IOLs, have been reported to induce a lower rate of PCO.

In recent years, IOL-design has undergone significant changes and there has been a general shift toward acrylic IOL materials, as well as sharp posterior edges for IOL optics. The square edge aims to inhibit the lens epithelial cell ingrowth between the capsule and the IOL surface. Comparative studies have established that the hydrophobic Acrysof® IOL (Alcon Inc) have lower rates of PCO and Nd:YAG treatment compared with silicone and PMMA lenses. When these comparative studies started the only square-edged lens on the market was the Acrysof® IOL. This lens remained the only square-edged IOL until 2001, when the CeeOn Edge®
(Pharmacia and Upjohn) and the Sensar® AR40(AMO) were introduced.

However, in a recent retrospective study by Vock et al.,\textsuperscript{152} the protective effect of the square edge lenses has been questioned. In their study, 143 eyes implanted with either MA60BM Acrysof® or a silicone lens (SI-30NB or SI-40, both Allergan) were examined for presence of PCO using digital images. The silicone IOLs had less after cataract ten years after surgery, 42% of the patients with Acrysof acrylic lenses and 18% of patients with silicone lenses implanted had been treated with Nd:YAG laser capsulotomy.

Even though recent improvements in intraocular lens technologies have reduced vision disturbing PCO, it is still a common complication after cataract extractions.\textsuperscript{137} Furthermore, increasing patient expectation for perfect quality of vision following cataract surgery has led to an increased demand for posterior capsulotomies even for minor PCO.\textsuperscript{158}
AIMS OF THE STUDY

The overall purpose of this thesis was to longitudinally study different aspects of cataract surgery on a long-term basis.

The specific aims were:

- To analyze the subjective and objective visual functional results at the time of surgery, and compare with the long-term outcomes.

- To determine if there are any gender-related differences in long-term cataract surgery outcome.

- To analyze the long-term visual functional results after cataract surgery in patients with diabetes, and compare the results with the outcomes of non-diabetics.

- To investigate the long-term results in younger cataract surgery patients, and to analyze the incidence of posterior capsular opacification and treatment with Nd:YAG laser.

ETHICS

The study was approved by the local Ethics Committee at Umeå University. Informed consent was obtained from all patients at surgery and at each follow-up.
PATIENTS AND METHODS

Study design and study population

The papers in this thesis are based on prospective data from a population-based cohort of all adult patients having surgery for senile and presenile cataract at one clinic during a one-year period. Between June 1st, 1997 and May 31st, 1998, all patients who underwent cataract surgery with IOL implantation at Norrlands University Hospital in Umeå, Sweden, were prospectively registered. The admitting area is situated in the northern part of Sweden and has a population of about 182 000 people with about 4 inhabitants per square kilometer. Our population represents 2% of the inhabitants in Sweden.

At baseline, all cataract surgery in the region was performed at the University Clinic. As a result of the Swedish Health Care Policy at that time, there were no private surgery alternatives, and patients very seldom crossed county borders to obtain treatment during the study period.

Inclusion and exclusion criteria

During the one-year period, 928 cataract surgeries were performed. Excluded from the study were 38 patients who had cataract extractions for reasons other than restoring vision or combined with other types of surgery, for example posterior segment procedures, glaucoma filtering surgery, or corneal transplants. Also excluded was
one patient who was scheduled for cataract surgery without IOL implantation. Patients with dementia or whose mental status was too poor to enable them to participate with the questionnaire, were also excluded (n=17). At the postoperative follow-up, 4-8 weeks after surgery, 13 patients did not show up, and 17 were deceased. Five patients denied to participate already at the time of surgery. Thus, the base cohort included 837 senile and presenile cataract cases. Twenty-seven patients (3%) had surgery on both eyes during the time-period studied, resulting in 810 cataract surgery patients finally included in the study.

Examinations

The patients were examined at the following occasions:

- A few weeks before cataract surgery.
- Between 4-8 weeks after surgery.
- Five years after surgery.
- Ten years after surgery.

Data collected before and shortly after surgery

All patients were examined a few weeks before surgery. Included in the examination were presenting visual acuity (PVA), best corrected
visual acuity (BCVA), tonometry, keratometric readings, and a slit lamp examination of both eyes.

PVA at distance, i.e. the visual acuity with the habitual correction glasses worn by the patient, or if the patient did not use glasses, without spectacles, was tested using a Monoyer-Granström letter chart. In the same way the BCVA, i.e. the visual acuity with the additional correction needed to obtain the best possible visual acuity, was recorded. It has been pointed out earlier that the patients’ subjective visual function is more dependent on the visual acuity in the better eye. Since the better eye is seldom the operated eye, both variables were included. Furthermore, this also explains why some of the patients had a Snellen VA of 20/20 (=1.0 decimal VA or logMAR 0.0) or better on their better seeing eye before surgery.

Data concerning age, sex, presence of pseudo-exfoliations, surgery on right or left eye, and of first and second eye surgery was recorded for each patient.

Presence of amblyopia, or any history of past ocular diseases such as, retinal detachment or central vein occlusion was recorded. Present ocular co-morbidity, like glaucoma, diabetic retinopathy, or age-related macular degeneration was noted.

Between four and eight weeks after the surgery the first follow-up examination was performed. The same eye examination as before surgery was conducted. Also, data on the surgery, the type of IOL, any complications such as zonular rupture and/or vitreous loss was added.
The questionnaire

The questionnaire used was a Swedish translation of the Visual Function-14 (VF-14) questionnaire. This is a well-validated instrument to assess visual function in cataract patients. It was developed in the United States by Steinberg et al.,\textsuperscript{62} and has been accepted for use in various translated versions in Europe.\textsuperscript{159} Changes in visual function can be assessed by analyzing questionnaire responses before surgery and compare with after surgery. The following set of functional activities was included in the questions from which the VF-14 is derived:

1. Reading small print, such as labels on medicine bottles, a telephone book, or food labels;
2. Reading a newspaper or book;
3. Reading a large-print book or newspaper or the numbers on a telephone;
4. Recognizing people when they are close to you;
5. Seeing steps, stairs, or curbs;
6. Reading traffic, street, or store signs;
7. Doing fine handwork such as sewing, knitting, crocheting, or carpentry;
8. Writing checks or filling out forms;
9. Playing games such as bingo, dominos, card games, or mahjong;
10. Taking part in sports such as bowling, handball, tennis, or golf;
11. Cooking;
12. Watching television;

13. Daytime driving;

14. Nighttime driving;

For each of the 14 items, patients are asked whether, even with glasses, they have any difficulty in doing the activity. Allowed responses are yes, no, or do not do the activity for reasons unrelated to vision. If respondents answer positively, that they have problems, they are asked to rate whether the amount of difficulty they currently have with the activity is “a little”, “a moderate amount”, or “a great deal” or whether they are “unable to do” the activity because of their vision. The exact wording of each of the 14 items and the associated response options are provided in the appendix.

According to the instructions outlined by Steinberg et al., each activity is scored from 0 to 4 corresponding to whether the respondent is “unable” to do the activity, or “can with great difficulty”, “can with moderate difficulty”, “can with little difficulty”, or “can with no difficulty” do the activity. All scored items are averaged and multiplied by 25. The final VF-14 score can range from 0 (unable to do all applicable activities because of vision) to 100 (able to do all applicable activities without difficulty). An item is not included in scoring if patients do not do the activity for a reason other than their vision (e.g., individuals who had never cooked for themselves or had never taken part in sports), and no minimum number of applicable items is therefore required.

A few days before surgery, the questionnaire was sent by mail to all patients and brought to the clinic at the day of surgery. The nurses
involved were trained to check that the questions had been understood and completely answered. About one month after the patients had received their prescription glasses, they were by mail again asked to answer the same questionnaire. The mean time from date of surgery to return of the second questionnaire was 3.7 (± 1.4) months (SD).

Five and ten years after surgery, a similar questionnaire was mailed to all surviving patients who were able to participate. Those who also had the eye examination delivered the questionnaire to the clinic, and those who were not examined mailed the questionnaire to the research team.

Data collected 5 and 10 years after surgery

Five and ten years after surgery, the patients still alive were offered an eye examination and once more asked to answer the questionnaire. After the studied started in 1997-98, the patients’ hospital records have been computerized, which makes it fairly easy to locate patients. Phone-calls were made to all patients alive, scheduling them for the examination. Some patients with obvious dementia were at that time excluded from the study. Since our region is sparsely populated, with long-distances to travel, some of the patients were offered the examination at their nearest health care center. In this way, the participation rate at five years was as high as 90% of the survivors for the questionnaire and 79% for the examination. At the ten-year follow-up, 85% answered the questionnaire, and 73% were examined.
The major reason for not participating with the eye examination was either illness/old age, or reluctance to travelling.

At the examination before surgery and 4-8 weeks postoperatively, visual acuity was measured with the Monoyer-Granström letter chart, which expresses acuity measures in decimals.

Visual acuity measures the ability to detect small details at a distance. The results from visual acuity testing indicate the foveal function, the most sensitive part of the retina. The size of the retinal image depends upon the size of the object and its distance from the eye. The further away an object is located, the smaller the retinal image. The angle that the image subtends at the nodal point of the eye is the visual angle. By combining the two factors of size and distance, it is possible to determine the minimum visual angle, that is, the smallest retinal image that can be discriminated. The so-called normal eye can identify an entire letter subtending an angle of 5 minutes of arc and any component of a letter subtending 1 minute of arc. Many persons, however, can resolve letters subtending a smaller visual angle.

In many English speaking countries, visual acuity is expressed in Snellen fractions. The fractions, 20/20, 20/30 etc., are measures of visual acuity at a specified distance. The first number represents the test distance, 20 feet. The second number represents the distance that the average eye can see the letters on a certain line of the eye chart. A visual acuity of 20/20 is considered a normal acuity in healthy adults.

The guidelines for publications in ophthalmological journals often recommend Snellen acuity charts. This is why some of the tables in
the papers included in this thesis, present visual acuity as Snellen acuity.

At the five and ten year follow-ups, the same examination was conducted but the early treatment diabetic retinopathy (ETDRS) chart was used for testing VA. The ETDRS acuity test was developed to improve the evaluation of the changes in vision following panretinal photocoagulation in patients with diabetic retinopathy. The advantage with this method is that it describes changes in visual acuity more accurate.

When using a Snellen or a decimal chart, there are different numbers of letters on each line, and also the individual lines are not equally spaced. The inadequacies in the decimal acuity tests, such as the Monoyer Granström letter chart and the Snellen acuity chart, makes it impossible to properly evaluate the acuity data and to compare data from study to study.

The ETDRS test has a specific design including:

- The same number of letters per row (5 letters)
- Equal spacing of the rows on a log scale (the rows are separated by 0.1 log unit).
- Equal spacing of the letters on a log scale.
- Individual rows balanced for letter difficulty.

When the ETDRS charts were presented by Bailey & Lovie in 1976 and introduced in the Early Treatment Diabetic Retinopathy Study by Ferris et al. in 1982, it was a time-consuming test not always well
accepted by the patients. Therefore, Camparini et al presented, in 2001, the ETDRS-Fast, which is the method we used five and ten years after surgery.\textsuperscript{160} In the statistical methods section, the scientifically accepted method of conversion from the decimal visual acuity results to the logarithmic ETDRS results is described. The ETDRS acuity testing is expressed as logMAR acuity (the logarithm of the minimal angle of resolution). A conversion table, presenting VA with the Monoyer Granström letter chart, the Snellen acuity chart, and the EDTRS chart, is presented in the appendix (p. 104).

**Figure 8.**

The Monoyer-Granström letter-chart and the ETDRS chart.

![Monoyer-Granström letter-chart](image1.jpg) ![ETDRS chart](image2.jpg)

Five and ten years after surgery, the participants had the same eye examination as before, and shortly after surgery. At the follow-up examinations there was also a subjective assessment of any present PCO, and a testing of low-contrast VA. Monocular low-contrast VA was tested using Sloan letter logarithmic translucent contrast charts.
(10% and 2.5%) (Precision Vision®) at a distance of 4 m. Participants who failed to read the largest letters at 4 m were tested at 1 m.

Contrast sensitivity measures the ability to see details at low contrast levels, e.g. grey of various shades on a white background. Visual information at low contrast levels is important in several situations, e.g. recognizing people and relate to facial expressions, in orientation and mobility where we need to see curbs, stairs and shadows, and in near vision tasks like writing. In traffic, the demanding situations are at low contrast levels, for example, seeing in dusk, rain, fog, snow fall, and at night. Measurement of contrast sensitivity can help us to better understand the complaints of a person whose visual acuity at high contrast (black letters on white) has not changed but whose vision has decreased at low contrast levels. Cataract, age-related macular degeneration, and PCO - among other ocular diseases - cause reduced contrast acuity.
Subgroups

Males/Females (Paper II).

In the baseline cohort, 283 (35%) of the total 810 patients were men, and 527 (65%) were women. Among these 810 patients, 237 (68 men and 169 women) had undergone cataract surgery on their first eye before the study started.

Diabetics (Paper III).

When the study started in 1997-98, 106 of the 810 patients were diabetics treated with insulin or oral anti-hyperglucaemic agents. Patients with dietary treatment only, were not included in the diabetic group.

The Modified Airlie House Classification was used when determining the level of retinopathy (Diabetic Retinopathy Study 1981163; Early Treatment Diabetic Retinopathy Study Group (ETDRS), Report no. 12:1991).164 The four levels of DR were as follows, I:no DR, II:mild non-proliferative DR (NPDR), III:moderate-severe NPDR, and IV:proliferative DR (PDR). The degree of retinopathy was established at the slip-lamp examination.

Younger cataract surgery patients (Paper IV).

At the beginning of the study, 116 of the 810 patients in the cohort were between 30 and 64 years of age. At the ten-year follow-up, all the surviving participants were examined with slit-lamp examination for detection of any PCO.
Statistical methods

To be able to compare the visual acuity results using the Monoyer-Granström letter-chart with the results from the ETDRS-charts, and to evaluate changes of VA in an appropriate manner, the values were converted into a log scale using the method outlined by Holladay & Prager.\(^{165}\) In this method, the proper manner for computing the average visual acuity from any notation is to convert the value to the logMAR equivalent and then take the average of the logMAR values. The easiest way to compute the logMAR value is to convert to decimal notation and then take the negative of the logarithm, e.g., 20/20=1 and the log of 1 is 0, and 20/200=0.10 and the negative of the log is +1.0. The formulas for going from decimal to logMAR and back are:

\[
\text{LogMAR} = -\log (\text{Decimal Acuity})
\]

\[
\text{Decimal acuity} = \text{antilog (-LogMAR)} = 10^{-\text{LogMAR}}
\]

When using the ETDRS-chart, VA was scored as the total number of letters read correctly, and expressed as logarithm of the minimum angle of resolution (logMAR) units. Patients with failure to read any letters were tested using counting fingers (CF), hand movements (HM), and light perception (LP). For VA 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 LP=logMAR 3, in a similar manner as previously described.\(^{62,166}\)

To define changes of VA, the logMAR acuity after surgery was subtracted from the logMAR acuity before surgery. For example, VA before surgery =logMAR0.7 (decimal acuity 0.2) and after surgery
logMAR 0.1 (decimal acuity 0.8) indicates an improvement in VA of 0.6 logMAR units (0.7 – 0.1). Consequently, a negative value denotes worse VA after surgery. A decline in VA was defined as an increase in logMAR of 0.1 or more, compared with the VA recorded after surgery, for each eye, respectively.

Age-differences between groups were calculated by independent sample t-tests. Multiple linear regression analyses were used to determine the associations before surgery, postoperatively, and 5 years after surgery, between VF-total score and gender, controlling for age and BCVA of the better eye. Age and BCVA were modelled as continuous variables.

Since the VF-14 scores, and the VA-data were highly skewed, non-parametric Mann-Whitney U tests, and Kruskal-Wallis tests were used when analyzing the variables. Yates’ corrected chi-square tests were used to analyse the categorical variables in two-by-two tables, when appropriate.

The change in VA and VF-14 total score from postoperatively to 10 years after surgery, was calculated by paired Wilcoxon signed ranks test. Changes in trend were analyzed by chi-square tests for trend, and by linear by linear association.

Univariate ANOVA controlling for age was used to associate change in VF-total score and change in BCVA of the better eye.

A life-table analysis using Cox proportional hazard model was used to determine the risk for having treatment with Nd:YAG laser during the ten-year follow-up. The cumulative incidence described in this model
takes into account both length of survival and length of follow-up, and therefore more accurately describes the over-all risk.

The SPSS statistical software ver. 16.0 (Statistical Package for the Social Sciences for MS Windows, SPSS Inc., Chicago, IL), and Microsoft Office Excel software were used for statistical calculations. All statistical tests were two-sided and P<0.05 was considered statistically significant.
RESULTS

Cataract surgery demographics

The study included 283 (35%) men and 527 (65%) women, a total of 810 patients between the ages of 30-94 years at the time of surgery. The mean ages for the men and the women was 73.6 and 75.4 years respectively (P=0.03).

In Figure 9, the distribution of men and women in different age groups, at baseline in 1997-98, is shown.

![Figure 9](image)

Surgical technique and complications

The type of surgery performed was a sutureless, 3.2mm, clear corneal temporal-incision phacoemulsification with insertion of a foldable intraocular lens (IOL). Four surgeons were involved in the procedures. The vast majority (99.5%) received a posterior chamber intraocular lens, of which 94% were an Alcon MA60BM Acrysof®. This
lens is a 3-piece IOL, with a 6 mm diameter acrylic optic, and PMMA haptics, with a total length of 13.0 mm.

The complication rates of posterior capsule and/or zonular rupture and vitreous loss were, in all 810 cases 5.7% and 2.7%, respectively.

**Demographics 5 and 10 years after surgery**

In Figures 10a, and b, the patient cohort flow-chart, five and ten years postoperatively is shown. Five years after surgery, 220 (27%) of the 810 patients were deceased. Of the 590 (73%) patients still alive, 47 (8%) suffered dementia, 6 (1%) denied to participate with the questionnaire, and 7 (1%) could not be located.

Five hundred thirty patients (530/590=90%) answered the questionnaire, and 467 (467/590=79%) had the examination as well. The patients who only answered the questionnaire were significantly older (80 years) compared with those who also had the eye examination (77 years)(P=0.02). No significant differences in sex were found between the dropouts and those included.

At ten years, 401 (49%) of the initial 810 patients were deceased. Of the 395 still alive, 41 (10%) had dementia, 8 (2%) refused to participate, and 11 (3%) could not be located (Figure 10b).

Ten years postoperatively, three hundred thirty five (335/395=85%) patients participated with the questionnaire, and 289 (289/395=73%) were examined. Those who only participated with the questionnaire were significantly older (82 years) compared with the patients who had the examination as well (78 years), (P=0.017).
Figure 10a.

Patient cohort flow-chart 5 years after surgery

Figure 10b.

Patient cohort flow-chart 10 years after surgery
In Table 1, the demographics 5 and 10 years postoperatively are presented.

**Table 1.**

<table>
<thead>
<tr>
<th></th>
<th>No. of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The 5-year data</strong></td>
<td></td>
</tr>
<tr>
<td>5-year VF-14 data</td>
<td>530 (90)</td>
</tr>
<tr>
<td>5-year VA and VF-14 data</td>
<td>467 (79)</td>
</tr>
<tr>
<td>Mean age 5 years postoperatively</td>
<td></td>
</tr>
<tr>
<td>Mean ±SD</td>
<td>76.9±10.6 years</td>
</tr>
<tr>
<td>Max/min at surgery</td>
<td>30-94 years</td>
</tr>
<tr>
<td>Males</td>
<td>177 (33)</td>
</tr>
<tr>
<td>Patients operated on both eyes after 5 years</td>
<td>376 (71)</td>
</tr>
<tr>
<td><strong>The 10-year data</strong></td>
<td></td>
</tr>
<tr>
<td>10-year VF-14 data</td>
<td>335 (85)</td>
</tr>
<tr>
<td>10 year VA and VF-14 data</td>
<td>289 (73)</td>
</tr>
<tr>
<td>Mean age 10 years postoperatively</td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>78.5±10.7 years</td>
</tr>
<tr>
<td>Males</td>
<td>107 (32)</td>
</tr>
<tr>
<td>Patients operated on both eyes after 10 years</td>
<td>274 (82)</td>
</tr>
</tbody>
</table>
Subjective visual ability (paper I)

Five years after surgery, the median VF-14 total score of all patients was 96.7. The surviving patients were divided into three groups depending on whether they only had one eye operated, first-eye surgery before the study started, or second-eye surgery before the 5-year follow-up. The VF-14 score before and after surgery was significantly lower in the group that had second-eye surgery before the follow-up, 5 years later compared with the two other groups (P=0.013 before surgery, and P=0.001 after surgery). There was a statistically significant reduction in the V-14 total score 5 years postoperatively in all groups except patients who had second-eye surgery before the follow-up (P=0.047 and P=0.001, respectively).

In Table 2, the VF-14 scores for all patients before surgery, 4 months postoperatively, and 5 years after surgery are presented.

Table 2.

<table>
<thead>
<tr>
<th>All patients</th>
<th>Before surgery</th>
<th>After surgery</th>
<th>5 years later</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VF-14 score</td>
<td>0.001*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>71.4±23.5</td>
<td>92.3±15.5</td>
<td>86.9±21.3</td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>77.1</td>
<td>100</td>
<td>96.7</td>
<td></td>
</tr>
<tr>
<td>Q1:Q2</td>
<td>58.3:90.4</td>
<td>92.2:100</td>
<td>83.3:100</td>
<td></td>
</tr>
</tbody>
</table>

Q1=the lowest quartile; Q3=the highest quartile.

*Change in VF-14 postoperatively versus 5 years after surgery
Visual acuity results (paper I)

A the five-year follow-up, there were no significant differences in presenting visual acuity (PVA) and BCVA in the operated eye between the 3 patient groups. However, there was a significant difference in presenting visual acuity and BCVA in the fellow eye and between BCVA in the better seeing eye (P=0.000, P=0.000, and P=0.007, respectively). Patients who had first-eye surgery between June 1\textsuperscript{st}, 1997, and May 31\textsuperscript{st}, 1998, and second-eye surgery before the follow-up 5 years later had significantly better visual acuity in the better-seeing eye compared with those who had first-eye surgery before June 1\textsuperscript{st}, 1997, and those who had only one eye operated on. A significantly larger proportion of patients had co-morbidity in the group that had first-eye surgery before the study started. (P=0.000).

Changes in VF-14 total score and visual acuity (paper I)

When comparing the subjective (VF-14 total score) and objective (VA results) visual function results five years after surgery with the postoperative (a couple of months after surgery) results, we found that 22\% of the patients had a reduction of more than 10 points in their VF-14 score, and that 37\% had lost more than 0.1 logMAR of visual acuity in the operated eye. Age-related macular degeneration and glaucoma were the most common diagnoses explaining the reduction in subjective and objective visual function.

A regression analysis was conducted showing significant associations
between the changes in the VF-14 total score and BCVA in the better eye postoperatively compared with 5 years after surgery, after controlling for age (P=0.0001). All the independent variables (age, VF-14 score after surgery, co-morbidity) were highly significant in explaining the VF-14 score 5 years after surgery. The adjusted $r^2$ value for the model was 0.53.

**Women and men (paper II).**

At the 5-year follow-up, 353 women and 177 men participated with the questionnaire, and 311 women as well as 156 men were examined. After 5 years, 75% of the women had undergone cataract surgery on both eyes, compared with 63% of the men, which is a significant difference (P=0.005).

The women were significantly older than the men at all occasions. The mean age 5 years after surgery was 78 years (±10), compared with 75 years (±11.6) for the men (P=0.009).

In figure 11, the subjective visual function (VF-14 total score) before surgery, postoperatively, and 5 years after surgery is presented. Both before surgery, and at the follow-ups, the median VF-14 scores were significantly lower for the women.
After adjusting for age and VA of the better eye, the difference in the VF-14 score remained before surgery and postoperatively (P=0.000 and P=0.036, respectively) but not 5 years after surgery (P=0.16). The results were the same regardless of if one or both eyes had undergone cataract surgery.

There was a significant difference between men and women in the longitudinal changes in VA of the better eye 5 years after surgery compared with postoperatively. A higher proportion of women were found to have a significant decline in VA of the better eye of more than 0.11 logMAR units. Regarding the operated eye, no differences were detected.
When investigating the individual responses in the questionnaire, the women had significantly worse self-assessed visual ability for several questions, for instance reading, doing handwork and driving. If the patient did not participate in a specific activity, i.e. driving, the item was not included in the scoring. A major part of the women did not take part in activities like sports and driving, but on the other hand they participated more often than men in areas like cooking.

**Diabetics (paper III)**

Five years after surgery, 42% of the diabetics compared with 25% of the non-diabetics were deceased (P=0.001). Fifty-seven of the 63 diabetics, still alive five years after surgery, participated with the questionnaire, and 47 of them were examined. VA data and degree of DR of the 10 diabetic patients who were not examined at 5 years was collected from their records. This was possible as the routine diabetic care in Sweden includes retinal imaging with a fundus camera every to every other year, and at the time of the study, VA examinations as well.

At the time of surgery, 60% (34/57) of the diabetics were treated with oral anti-hyperglucaemic agents, and 40% (23/57) received insulin. After 5 years, another two patients were treated with insulin.

Regarding the level of diabetic retinopathy, 65% (37/57) were unchanged, and 33% (19/57) had progressed. One patient (2%) had improved, since the removal of the cataract had made treatment of PDR, including macular oedema, with photocoagulation possible.
No significant differences between the 45 diabetics who had died before the 5-year follow-up, and the 57 surviving diabetics, regarding VF-14 score, BCVA of the operated eye 4 months postoperatively, and degree of DR could be detected.

At the 5-year follow-up, the diabetics had somewhat lower VF-14 and VA results, compared with the non-diabetics. However, these differences were not significant.

When investigating the longitudinal changes in the VF-14 and VA results, there was a decrease among both the diabetics and the non-diabetics. Again, the differences between these two groups were not significant (P=0.87 and 0.76, respectively).

**Younger cataract patients (paper IV)**

Ten years after surgery, 12% (14/116) of the younger cataract surgery patients (30-64 years) were deceased in comparison to 58% (401/694) of those 65 years or older at surgery.

A total of 95 (93%) patients under the age of 65 years at surgery, and 240 (82%) over 65, answered the questionnaire. The examination was conducted on 86 (84%) of the 102 younger patients, and on 203 (69%) of the older patients still alive. A larger proportion of the older patients were women, 72% compared with 57% of those under the age of 65.

When evaluating the visual functional longitudinal changes, there were no significant differences between the younger and the older
cataract surgery patients before surgery and 4 months after surgery. However, after ten years, the patients less than 65 years at surgery had a significantly better VF-14 score (median 98.5 compared with 95.0 for those over 65, (P=0.000)).

Regarding the change in BCVA of the operated eye, 68% of the patients under 65 years of age at surgery, had better or unchanged visual acuity results at the 5-year follow-up compared with a couple of months after surgery. This is a significant larger proportion compared with the older patients where 42% had better or unchanged BCVA of the operated eye (P<0.0002).

Ten years after surgery, 28% of all the patients that participated with the questionnaire had been treated with Nd:YAG capsulotomy because of posterior capsular opacification. A significantly higher proportion of those under the age of 65 at surgery were represented in this group, 37% compared with 20% of the older patients (P=0.003). When looking specifically at the Nd:YAG laser treatments of the younger patients, we found that this was especially frequent among the youngest, 44% of those aged 30-54 compared to 32% of the patients aged 55-65 years at surgery.

There were significant differences between the younger and the older patients in the low-contrast VA results, both when testing with the 10% and the 2.5% charts (P=0.000). However, no differences in the low-contrast VA results between the younger patients that had been treated with Nd:YAG laser, and those that were not treated, could be detected.

A life-table analysis was performed to enable an evaluation on the risk
of needing treatment with Nd:YAG laser over the ten-year period studied (Figure 12). Ten years after surgery, the cumulative proportion of “no capsulotomy” was 72% for patients less than 65 at surgery and 85% for the patients 65 years or older. At 2.5 and 6 years postoperatively, there was a steepening of the curve, indicating an increased risk for YAG laser treatment for the patients less than 65 years of age at surgery.

**Figure 12.** A survival curve showing the cumulative proportion of “no capsulotomy” (no treatment with Nd:YAG) in patients less than 65 years and those 65 years or older at surgery, from time of surgery to 10 years.
DISCUSSION

The study design, validity and reliability

In this prospective population-based cohort study 90% of the patients still alive five years after surgery, and 85% still alive at ten years, participated with the questionnaire. Five and ten years postoperatively, 80% and 73%, respectively, were also examined. In a cohort study, the major potential selection bias is loss to follow-up. *Bias* is a systematic error in a study that might influence the results. This kind of systematic error might lead to a distortion of study results that makes the association stronger or weaker than it really is. The most common classification divides biases into three categories: selection bias, information bias or confounding.\textsuperscript{167} 

In order to reduce *selection bias*, and apply the results on the population as a whole, great efforts were made to minimize data losses. At the five and ten year follow-ups, phone-calls were made to all the patients still alive, in order to offer them a scheduled appointment for the follow-up examination. Instead of mailing an invitation letter, this manner probably increased the participation rate at the follow-ups, minimizing the possibility that findings based on the cohort were biased by loss to follow-up. 

*Information bias* can occur when there is a systematic inaccuracy in measurements. To reduce information bias, the same research nurse tested the visual acuity of all participating patients at the five-and ten year follow-ups. At the eye-examination five years postoperatively, two ophthalmologists conducted the slit-lamp examinations. Ten
years postoperatively, all examinations were performed by one ophthalmologist.

*Confounding* comes from the Latin word, confundere, which means “to mix together”. It refers to the mixing of the effect of a variable which may influence the comparability between individuals. In order to control for confounding in the analyses, adjustments were made for age, first or second eye surgery, BCVA of the better eye, and co-morbidity.

The concept of *validity* concerns the degree to which a measurement or study reaches a correct conclusion. If, in a study population, the results are not valid, there is little reason to suspect that those results will apply to other populations. *Internal validity* is the extent to which the results of an investigation accurately reflect the true situation of the study population. It is important for a study to have internal validity, the ability to measure what it sets out to measure.\(^{168}\)

In this study, at all follow-ups, the VF-14 questionnaire was used to determine the subjective visual function. This questionnaire is a well-validated instrument to assess visual function, presented by Steinberg et al. in 1994.\(^6\) It has thoroughly been described in the “material and methods“ section.

Patient-reported questionnaires in the assessment of cataract surgery is now widely appreciated.\(^{169,170}\) There are several questionnaires developed for this matter, such as the VF-14,\(^6\) the Visual Disability Assessment (VDA),\(^{171}\) and the Catquest.\(^{172}\) Some of the limitations with these questionnaires are the validity of the scoring method and the validity of the items included.\(^{173}\) Therefore, to evaluate if an outcome method is still valid, *Rasch-analysis* can be performed. In
brief, Rasch analysis is a mathematical model developed by the Danish mathematician George Rasch, which attempts to estimate the values of a latent variable on an interval scale from items that form an ordinal scale. Disability can be considered to lie on a ruler, and the range of disability is expressed in log-odd units. The Rasch-model has been used in the validation of several vision-specific questionnaires, for example the Activities of Daily Vision Scale, the NEI, and the Catques-9SF. In a study by Lee et al from 2006, a Rasch methodology analysis proved the VF-14 to be an appropriate measure of visual functioning in cataract surgery patients. However, when investigating the separate questions, the item “taking part in sports” showed low applicability, probably due to the old age of the participants.

*External validity or generalizability* is the extent to which the results of a study are applicable to other populations. This is of particular interest in clinical research in determining if a finding can be applicable in a clinical practice. The cohort described in this thesis, well represents the Swedish cataract population with 65% women, and a mean age at surgery of 73.6 and 75.4 years, for the men and the women, respectively. The rate of cataract surgery was 5.2 per 1000 population, which is well comparable with that of the country as a whole at the time. Given the internal and external validity discussed above without strong bias or confounding factors, the results in the papers could therefore be generalized to a Swedish population.

This thesis describes a cohort including all patients having cataract surgery in a defined area during a one-year period. Population-based studies, as the present one, remain the most valid to determine the
prevalence and incidence of a disease and to better treat these diseases. The Swedish health care system is especially suitable for these evaluations since it is comparatively easy to locate patients even five and ten years after surgery, which reduces the drop-out rate. Furthermore, at the time of the study, the likelihood of cataract patients having surgery outside county borders was negligible which also increases the validity. Repeated surveys over time may also demonstrate the impact of preventive strategies. Long-term follow-up studies of existing population-based cohorts, provide important insights in risk factors and disease pathogenesis and allow documentation of the incidence of diseases, and changing levels of risk factors over time. In the last 30 years, the role of some of the most important risk factors for eye diseases have been detected using prospective follow-up of population-based cohorts, eg. the role of hyperglycemia as a risk factor for diabetic retinopathy in WESDR, the role of hypertension in risk of AMD in the Beaver Dam Eye Study.

Moreover, some associations are seen only with longer-term follow-up, for example the role of dietary factors in AMD progression, presented in the Blue Mountain Eye Study, was seen in the 10-year but not in the five-year follow-up study.

The integration of current best evidence with clinical practice is referred to as evidence-based medicine. Medical practice must be evidence-based as a result of tight budgets, waiting lists, and the need to target resources. From the individuals’ point-of-view it is also valuable to receive information on the long-term results after surgery.
Visual outcome analysis

Five years after surgery, more than half of the patients had unchanged or better VF-14 score compared with a couple of months postoperatively, which must be considered as a favorable outcome. More than three-quarters had a decline of less than 10 points. Almost two thirds, or 296 (63%) of the 467 patients examined, had preserved VA (less than 0.1 logMAR deterioration) in the operated eye 5 years after surgery.

In studies assessing cataract surgery outcome one must be aware of the fact that the patients before surgery, in most instances, have two eyes with varying degree of cataract, or that the fellow eye might already have had surgery. At the five-year follow-up, the patients were divided into three groups based on whether they had cataract surgery on one or two eyes. The first group had first eye surgery, the second group had their first eye operated on before the study started, and the third group had second eye surgery sometimes between baseline and the five-year follow-up.

At baseline, the VA was measured on a decimal chart, and at the five- and ten year follow-ups, the EDTRS chart was used. It would have been preferable to utilize the same VA test charts at all occasions, but when this study commenced the EDTRS charts were not an option. At each examination, the visual acuity was measured on both the operated eye, and the fellow eye. The better-seeing eye is the eye with the best VA, most commonly, but not always, equivalent to the eye not having surgery. In outcome studies the VA-result is often associated with the subjective visual function assessed by a questionnaire. In these cases it is essential to assess the VA of the patients’ better-
seeing eye, as the subjective visual function has been shown to depend more on the vision of the better eye than the worse eye.\textsuperscript{62,180}

At the five-year follow-up, 29% of the patients had only one eye operated. This patient group sustain their subjective and objective visual function well, probably because they do not have a significant vision disturbing cataract in the fellow eye.

The patients in the group that had first eye surgery before the study started, in 1997, had a significant decrease in their VF-14 total score five years after surgery compared with postoperatively. Only 26% had a BCVA better than 20/25 of the fellow eye. Five years after surgery, these patients presented a larger proportion of ocular co-morbidity, which might have been true also when they entered the study. The importance of co-morbidity in explaining deterioration of visual function has previously been discussed by Lundström et al. in 2005.\textsuperscript{181} The surgical methods used before 1995 at our clinic, ie. extracapsular cataract extraction with an incision length of more than 6mm, may not have been as effective as phacoemulsification in restoring VA and visual function. The frequency of posterior capsular opacification might also have been higher with older lens materials. There was no significant difference in age between the groups. Hence, the patients in the group that had first eye surgery before the enrolment in 1997 were younger when they first requested surgery.

The patients who had their first eye operated on in 1997-98 and had second eye surgery before the follow-up 5 years later had a significantly lower VF-14 score before surgery and at the first postoperative follow-up (about 4 months after surgery) compared with the other two groups. The reason for this is probably that they
had cataract on both eyes when they were enrolled. When investigating the change in VF-14 score five years after surgery compared with postoperatively, there was no significant decrease in this patient group. This is expected, as in this group, the fellow eye surgery had improved the VA, and VF-14 total score.

The findings of this study are in accordance with previous research, and show that the most important reason for the worsening of both the subjective visual function (VF-14 total score), and the VA (BCVA operated eye), was age-related macular degeneration (60% and 47% respectively). The issue whether or not ARM is augmented by cataract surgery has intensely been discussed in several papers. There are studies showing both the benefits, and risks, with cataract surgery on ARM-patients. The present study was however not designed to analyze the potential risks with cataract surgery, nor answer the question if cataract surgery might exaggerate the development of ARM.

**Gender-related differences**

In this population-based study, men came earlier to surgery as they had significantly better BCVA of their better-seeing eye before surgery. These findings deviate from several previous studies who before surgery found no significant difference in VA of the better eye between men and women. These results might be explained by a larger proportion of men being active car-drivers in the older age groups, and therefore require better vision. In a previous study on visual function in car drivers from 2006, 66% of the active drivers
before surgery were men. Car-driving especially in darkness and dusk is challenging for people with cataracts. The impact of lower VA, glare sensitivity and reduced contrast sensitivity might explain why, in the present study, it was found that men came earlier to surgery.

Before surgery and a few months postoperatively, the women experienced significantly more subjective visual functional impairment compared with the men, even after adjustment for age and BCVA of the better eye. This is consistent with previous research that the pre-operative VF-14 score was slightly better for men. In this study the difference 5 years after surgery was less obvious. The women still had a lower VF-14 score but after adjusting for age and BCVA of the better eye, the difference was not significant. The findings agree with previous research that women score worse than men in self-reported visual function.

Gender-related differences have been observed in objective and self-reported perceived health also in general health care. Women are believed to be more prone to a poor self-rated health status and they report more physical symptoms than men. Previous health researchers conclude that men and women differ in how symptoms are perceived, evaluated and acted upon. Some of them support the hypothesis that women have a higher selective attention to their bodies. Traditional ideals not to succumb to weaknesses among men might to some part explain these gender-related differences.

When evaluating the responses to specific questions, significant gender-related differences were found regarding most items. Women were more likely than men to report that their vision limited their ability to read road signs, to recognize people across the street, and to
drive at night. Most elderly women did not take part in sport-activities and were not active car-drivers, which caused a low response-rate for these questions. This is also true for men regarding cooking. The VF-14 questionnaire has been revalidated with Rasch analysis. However, it has not been validated to determine if it is appropriate for use in both women and men. Further studies are required to establish the validity of questionnaire instruments and one way might be to validate questionnaires separately for men and women.

The results of this study illustrate that gender differences in subjective and objective visual function exist among cataract patients before and after surgery, as well as on a long-term basis. These gender-related differences in the perception of visual function should be considered when analyzing questionnaire results regarding visual function.

**Visual function and progression of retinopathy in diabetics**

When this population-based study was initiated, in 1997, 108 (13%) of the 810 participants were diabetics treated with either insulin or anti-hyperglucosaemic agents. Since the phacoemulsification surgery technique became widely accepted in the 1990s, fewer postoperative complications in diabetics, like cystoid macular oedema and progression of DR, have been reported. In the present study, progression of DR was seen in 37% of the diabetic patients 5 years after surgery, compared with postoperatively. This is a larger
proportion compared with the study by Mittra et al. from 2000\textsuperscript{97} (follow-up time 6-10 months after phacoemulsification), but it is consistent with the results by Antcliff et al. from 1997\textsuperscript{103} (follow-up time two years), Pollack et al. 1991\textsuperscript{190}(6 months) ,and Henricsson et al 1996\textsuperscript{191} (2 years). However, the considerably longer follow-up time most probably explain the higher percentage of progression in this study.

The question is whether this is a natural history of the disease or not. Paired-eye comparisons (one eye having cataract surgery, the other not operated on) have been conducted by Krepler et al in 2002,\textsuperscript{192} and Squirrel et al in 2002.\textsuperscript{104} None of these studies could detect any significant differences in DR progression rates between operated and non-operated eyes, although the reported progression rates were consistently and slightly higher in operated compared with non-operated eyes.\textsuperscript{104,192}

There were no significant differences in VF-14 score or in VA-results between the diabetics and the non-diabetics. As expected, the diabetics with PDR had the lowest BCVA of the operated eye at all examinations. However, they did not have a significantly greater longitudinal loss in median BCVA compared with patients with less DR. The majority of these diabetic patients had a considerably better VA of the operated eye at the 5-year follow-up compared with preoperatively. This indicates that cataract surgery is beneficial also for diabetics with PDR.

A larger percentage of the diabetics (42%) compared with the non-diabetics (25%) were deceased 5 years after surgery. This is probably due to other medical problems, like cardiovascular disease, being
more common among diabetics. The diabetics that had died before the 5-year follow-up did not have a significantly worse DR level at surgery compared with the diabetics who were still alive at the 5-year follow-up. However, previous studies on diabetes and complications have presented significant associations between levels of retinopathy and mortality.

Some limitations of the study should be noted. First, the number of surviving diabetics five years after cataract surgery is rather small compared with the non-diabetics. This is inevitable, since most patients operated for cataract are old and many of them die within five years after surgery. Diabetics have a shorter life-span than non-diabetics. However, a recently published paper found improved survival in diabetics. Age-adjusted survival rates increased from approximately 70% in 1985 to more than 80% in 2005, probably due to significant changes in cardiovascular prevention therapy.

The small insignificant differences in VA and VF-14 between diabetics and non-diabetics made power calculations necessary. At least 8000 patients would be needed in each group to reach significance – an impossible number of patients for any study with a 5-year follow-up.

A second limitation is that the preoperative level of DR was assessed by studying the patients’ records. At the follow-up five years after surgery any DR was determined at the slit-lamp examination. It would have preferable to compare retinal fundus photographs from all occasions. However, this was not possible since the cataract, in many cases, made it difficult to obtain a photograph sharp enough to evaluate. Furthermore, if the cataract was completely mature, the grading of any DR was impossible. If no information about DR was
recorded preoperatively, the level of DR at the postoperative follow-up, 4-8 weeks after surgery, was denoted as the preoperative DR.

**Cataract surgery outcomes in younger patients**

PCO is by far the most common complication after cataract surgery, and is considered a normal wound healing process. Almost 40% of the patients in the study less than 65 at surgery, had received Nd:YAG laser treatment 10 years after surgery compared with 20% of the patients 65 years or older. This is consistent with earlier observations, reporting a higher incidence of PCO in younger patients. The figures exceed previously published 2-year results on Nd:YAG capsulotomy rates after phacoemulsification and implantation of Alcon AcrySof® MA60BM IOLs, of 2.7%. A similar high rate of Nd:YAG capsulotomy, as found in this study, was presented in a recently published article by Vock et al. In their retrospective study, 42% of 99 eyes (mean age 66.4 years) with acrylic hydrophobic lenses (MA60BMAcrysof® IOL, Alcon Inc) had received Nd:YAG laser capsulotomy after 10 years. However, the results from the study presented in this thesis do not indicate that the sharp-edged hydrophobic lenses lose their protectiveness against PCO after 10 years, as postulated by Vock et al. A considerable rise in the PCO rates was present as early as after 2.5 years with a deceleration six years after surgery (Figure 12).

In this study, the vast majority (90%) of patients less than 65 years of age, had a decline in VF-14 score of fewer than 10 points, ten years after surgery, and more than 60% had unchanged or better VF-14
total score. Eighty percent had preserved VA (less than 0.1 logMAR deterioration) in the operated eye 10 years after surgery. These long-term results must be considered a favorable outcome.

The lack of difference in low contrast VA, between the patients less than 65 at surgery that were treated or not treated with Nd:YAG laser, indicates that most of the patients in need for posterior capsulotomy already had received this at the 10-year follow-up. Because of the Swedish Social Security system it is considerably easy to receive an appointment with an ophthalmologist, and the cost for the patient is fairly modest. In view of the longer life-expectancy among younger cataract patients, stable visual functional results are important also decades after surgery.
CONCLUSION

Paper 1. Five years after cataract surgery, approximately 50% of the patients in the population-based cohort had unchanged or better subjective and objective visual function compared with the postoperative results. The main reason for the decline in VF-14 total score and the visual acuity results was age-related macular degeneration.

Paper 2. Women undergoing cataract surgery assess their visual function worse than men after adjustment for age and VA preoperatively and a few months postoperatively. These differences were not significant five years after surgery although the men had better BCVA of their better seeing eye. It is important to be aware of gender-related differences in perception when performing questionnaire-based outcome studies.

Paper 3. Five years after surgery, diabetics sustain their subjective and objective visual function at approximately the same level as non-diabetics. No significant differences between diabetics and non-diabetics regarding VF-14 total score, visual acuity or the longitudinal changes in visual function could be detected. Five years after surgery, only 33% of the diabetics had a progression in their DR. The data suggest that phacoemulsification is beneficial also five years after surgery in terms of visual and functional
improvement in diabetics with significant cataract.

**Paper 4.** Ten years after surgery, subjective and objective visual function remained stable in most patients younger than 65 years at surgery. Approximately 80% had unchanged or better VA of the operated eye, and 90% had less than 10 points decline in their VF-14 score. More than one-third had been treated with Nd:YAG because of vision-disturbing PCO. The cumulative proportion of “no capsulotomy” 10-years after surgery was 72% for those less than 65 at surgery, and 85% for the patients 65 years or older.

**FUTURE PERSPECTIVES**

In 2012, 15 years will have passed since the first patients included in this cohort had cataract surgery. The intention is to continue to follow the surviving patients 15 and 20 years postoperatively. The participation rate at the follow-ups completed so far has been high. However, in a cohort with mostly elderly people, as the one described in this thesis, it is inevitable that some will die. For the patients as well as for the health care providers it is important that long-time results are analyzed and published.

At the five-year follow-up, 530 cataract surgery patients participated with the questionnaire. After ten years there were still 335 people included in the study. Long-term, prospective, population-based studies after cataract surgery including data ten years postoperatively
are scarce. The Swedish health care system, in 1997, was especially suitable for these studies, because the risk for cataract patients to be operated outside county borders was small, and it is fairly easy to locate patients also after several years. The northern part of the country, in particular, is appropriate for these studies since private options for cataract surgery are insignificant.

Changes in the Swedish Health Care Policy, with a more favorable attitude towards private health care, and an increased freedom of choice, have resulted in a greater likelihood for patients to have cataract surgery outside the area of their registered residence. Furthermore, pre- and post-operative examinations in cataract surgery have been heavily rationalized, resulting in fewer follow-up occasions than previously. Today, a similar study like the one described in this thesis would be much more difficult to accomplish.
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APPENDIX

The original questions included in the VF-14 were as follows:

1. Do you have any difficulty, even with glasses, reading small print, such as tables on medicine bottles, a telephone book, food tables?

2. Do you have any difficulty, even with glasses, reading a newspaper or a book?

3. Do you have any difficulty, even with glasses, reading a large print book or large-print newspaper or numbers on a telephone?

4. Do you have any difficulty, even with glasses, recognizing people when they are close to you?

5. Do you have any difficulty, even with glasses, seeing steps, stairs, or curbs?

6. Do you have any difficulty, even with glasses, reading traffic signs, street signs, or store signs?

7. Do you have any difficulty, even with glasses, doing fine handwork like sewing, knitting, crocheting, carpentry?

8. Do you have any difficulty, even with glasses, writing checks or filling out forms?

9. Do you have any difficulty, even with glasses, playing games such as bingo, dominos, card games, mah-jong?
10. Do you have any difficulty, even with glasses, taking part in sports like bowling, handball, tennis, golf?

11. Do you have any difficulty, even with glasses, cooking?

12. Do you have any difficulty, even with glasses, watching television?

Do you currently drive a car?  ___Yes  ___No

If the answer is Yes, please answer questions 13 and 14.

13. How much difficulty do you have driving during the day because of your vision?

14. How much difficulty do you have driving at night because of your vision?

To questions 1-12, the possible answers are:

___Yes  ___No  ___Not applicable

If yes, how much difficulty do you currently have?

- A little
- A moderate amount
- A great deal
- Are you unable to do the activity?

To questions 13 and 14, the possible answers are:

- No difficulty
- A little difficulty
- A moderate amount of difficulty
- A great deal of difficulty

The first page of each questionnaire contained instructions regarding how to fill out the questionnaires (not shown). The wording of the questions and answering options of the questionnaires listed above have been translated into Swedish. The lay-out of the questionnaires and the print size has been considerably condensed to save space.
# Visual acuity conversion chart

<table>
<thead>
<tr>
<th>Snellen</th>
<th>Decimal</th>
<th>LogMAR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/10</td>
<td>2.00</td>
<td>-0.30</td>
</tr>
<tr>
<td>20/16</td>
<td>1.25</td>
<td>-0.10</td>
</tr>
<tr>
<td>20/20</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>20/25</td>
<td>0.80</td>
<td>+0.10</td>
</tr>
<tr>
<td>20/32</td>
<td>0.63</td>
<td>+0.20</td>
</tr>
<tr>
<td>20/40</td>
<td>0.50</td>
<td>+0.30</td>
</tr>
<tr>
<td>20/50</td>
<td>0.40</td>
<td>+0.40</td>
</tr>
<tr>
<td>20/63</td>
<td>0.32</td>
<td>+0.50</td>
</tr>
<tr>
<td>20/80</td>
<td>0.25</td>
<td>+0.60</td>
</tr>
<tr>
<td>20/100</td>
<td>0.20</td>
<td>+0.70</td>
</tr>
<tr>
<td>20/125</td>
<td>0.16</td>
<td>+0.80</td>
</tr>
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<td>20/160</td>
<td>0.13</td>
<td>+0.90</td>
</tr>
<tr>
<td>20/200</td>
<td>0.10</td>
<td>+1.00</td>
</tr>
<tr>
<td>20/250</td>
<td>0.08</td>
<td>+1.10</td>
</tr>
<tr>
<td>20/320</td>
<td>0.06</td>
<td>+1.20</td>
</tr>
<tr>
<td>20/400</td>
<td>0.05</td>
<td>+1.30</td>
</tr>
<tr>
<td>20/2000†</td>
<td>0.01</td>
<td>+2.00</td>
</tr>
<tr>
<td>20/20000∞</td>
<td>0.001</td>
<td>+3.00</td>
</tr>
</tbody>
</table>

*Log of Minimum Angle of Resolution

†20/2000=count fingers at 1 feet

∞20/20000=hand motion at 1 feet