

PREFERRED PRACTICE PATTERN®



Cataract in the Adult Eye

Prepared by the American
Academy of Ophthalmology
Cataract and Anterior Segment Panel

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As a service to its members and the public, the American Academy of Ophthalmology has developed a series of guidelines called Preferred Practice Patterns™ that **identify characteristics and components of quality eye care.**

The Preferred Practice Pattern® guidelines are based on the best available scientific data as interpreted by panels of knowledgeable health professionals. In some instances, such as when results of carefully conducted clinical trials are available, the data are particularly persuasive and provide clear guidance. In other instances, the panels have to rely on their collective judgment and evaluation of available evidence.

Preferred Practice Patterns provide guidance for the pattern of practice, not for the care of a particular individual. While they should generally meet the needs of most patients, they cannot possibly best meet the needs of all patients. Adherence to these Preferred Practice Patterns will not ensure a successful outcome in every situation. These practice patterns should not be deemed inclusive of all proper methods of care or exclusive of other methods of care reasonably directed at obtaining the best results. It may be necessary to approach different patients' needs in different ways. The physician must make the ultimate judgment about the propriety of the care of a particular patient in light of all of the circumstances presented by that patient. The American Academy of Ophthalmology is available to assist members in resolving ethical dilemmas that arise in the course of ophthalmic practice.

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Innovation in medicine is essential to assure the future health of the American public, and the Academy encourages the development of new diagnostic and therapeutic methods that will improve eye care. It is essential to recognize that true medical excellence is achieved only when the patients' needs are the foremost consideration.

All Preferred Practice Patterns are reviewed by their parent panel annually or earlier if developments warrant and updated accordingly. To ensure that all Preferred Practice Patterns are current, each is valid for 5 years from the "approved by" date unless superseded by a revision.



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INTRODUCTION

The Preferred Practice Patterns™ (PPP) series of guidelines has been written on the basis of three principles.

- ◆ Each Preferred Practice Pattern® should be clinically relevant and specific enough to provide useful information to practitioners.
- ◆ Each recommendation that is made should be given an explicit rating that shows its importance to the care process.
- ◆ Each recommendation should also be given an explicit rating that shows the strength of evidence that supports the recommendation and reflects the best evidence available.

In the process of revising this document, a detailed literature search of articles in the English language was conducted on the subject of cataract for the years 2000 to August 2005. The results were reviewed by the Cataract and Anterior Segment Panel and used to prepare the recommendations, which they rated in two ways.

The panel first rated each recommendation according to its importance to the care process. This “importance to the care process” rating represents care that the panel thought would improve the quality of the patient’s care in a meaningful way. The ratings of importance are divided into three levels.

- ◆ Level A, defined as most important
- ◆ Level B, defined as moderately important
- ◆ Level C, defined as relevant but not critical

The panel also rated each recommendation on the strength of evidence in the available literature to support the recommendation made. The “ratings of strength of evidence” also are divided into three levels.

- ◆ Level I includes evidence obtained from at least one properly conducted, well-designed, randomized controlled trial. It could include meta-analyses of randomized controlled trials.
- ◆ Level II includes evidence obtained from the following:
 - ◆ Well-designed controlled trials without randomization
 - ◆ Well-designed cohort or case-control analytic studies, preferably from more than one center
 - ◆ Multiple-time series with or without the intervention
- ◆ Level III includes evidence obtained from one of the following:
 - ◆ Descriptive studies
 - ◆ Case reports
 - ◆ Reports of expert committees/organization
 - ◆ Expert opinion (e.g., PPP panel consensus)

Evidence is that which supports the value of the recommendation as it relates to the quality of care. The committee believes that it is important to make available the strength of the evidence underlying the recommendation. In this way, readers can appreciate the degree of importance the committee attached to each recommendation and they can understand what type of evidence supports the recommendation.

The ratings of importance and the ratings of strength of evidence are given in bracketed superscripts after each recommendation. For instance, “[A:II]” indicates a recommendation with high importance to clinical care [A], supported by sufficiently rigorous published evidence, though not by a randomized controlled trial [II].

The sections entitled “Orientation” and “Background” do not include recommendations; rather they are designed to educate and provide summary background information and rationale for the recommendations that are presented in the Care Process section. A summary of the major recommendations for care is included in Appendix 1.



ORIENTATION

ENTITY

A cataract in the adult eye (ICD-9 #366.1).

DISEASE DEFINITION

A cataract is a degradation of the optical quality of the crystalline lens.

PATIENT POPULATION DEFINITION

Adults (18 years old and older) with cataracts.

ACTIVITY

Management of cataracts that interfere with a patient's functional status or an ophthalmologist's ability to manage other ocular conditions.

PURPOSE

The purpose in managing a patient with a cataract is to improve functional vision and the quality of life. Occasionally cataract surgery may be undertaken to aid in the management of other ocular diseases.

GOALS

- ◆ Identify the presence and characteristics of a cataract.
- ◆ Assess the impact of the cataract on the patient's visual and functional status and on quality of life.
- ◆ Inform the patient about the impact of a cataract on vision, functional activity, and natural history as well as the benefits and risks of surgical and other alternatives so that the patient can make an informed decision about treatment options.
- ◆ Establish criteria for a successful treatment outcome with the patient.
- ◆ Perform surgery when there is the expectation that it will benefit the patient's function and when the patient elects this option.
- ◆ Perform surgery when indicated for management of coexistent ocular disease.
- ◆ Provide necessary postoperative care, rehabilitation, and treatment of any complications.



BACKGROUND

EPIDEMIOLOGY

Cataracts are the leading cause of blindness worldwide and remain an important cause of blindness and visual impairment in the United States, accounting for approximately 50% of low-vision cases in adults over the age of 40.¹ Cataracts are the leading cause of treatable blindness among Americans of African descent age 40 and older and are the leading cause of low vision among Americans of African, Hispanic/Latino, and European descent.¹ The Eye Diseases Prevalence Research Group estimated that the number of individuals with cataracts will increase by 50% by 2020, based on United States (US) Census population estimates.²

There are several different types of cataracts: nuclear, cortical (spoke-like or oil droplet), subcapsular (anterior and posterior), and mixed. Each type has its own anatomical location, pathology, and risk factors for development. Several systems are available to classify and grade lens opacities.³⁻⁷ Nuclear cataracts consist of a central opacification or coloration that interferes with visual function. There are different types of nuclear cataracts, accompanied by either

brunescence, opalescence, or both.⁸ Nuclear cataracts tend to progress slowly and affect distance vision more than near vision. In advanced cases, the lens becomes brown and opaque.

Cortical cataracts can be central or peripheral and sometimes are best appreciated by retroillumination or retinoscopy. Patients with this type of cataract commonly complain of glare. When the entire cortex becomes white and opaque, the cataract is referred to as a mature cortical cataract.

Posterior subcapsular (PSC) cataracts can cause significant visual impairment if they affect the axial region of the lens. Posterior subcapsular cataracts are found more often in younger patients than are nuclear or cortical cataracts. Patients often have glare and poor vision with bright lighting, and their near vision is typically more affected than distance vision. Two population-based studies found that of the three types, PSC cataracts are associated with the greatest rate of cataract surgery.^{9,10} In an older population (mean age 79 years) undergoing cataract surgery, however, nuclear cataracts were most frequently encountered.¹¹

Studies have found racial differences in the prevalence of different cataract types. In the Salisbury Eye Evaluation Study, Americans of African descent had a four times greater chance of having cortical opacities than Americans of European descent, and Americans of European descent were more likely to have nuclear and PSC opacities.¹² The Los Angeles Latino Eye Study of individuals 40 years old or older found that cortical opacities were the most frequent type of lens opacity.¹³

NATURAL HISTORY

The natural history of all types of cataracts is variable, unpredictable, and is related in some ways to type. Any portion of the lens can become opaque. With age, the lens increases in thickness and weight. Continued production of lens fibers causes hardening and compression of the nucleus, known as nuclear sclerosis. Subsequently, the lens proteins undergo modification and aggregation, and they take on a yellow-to-brown coloration, changing the transparency and refractive index of the lens. Nuclear sclerosis and yellowing are considered a normal part of the aging process.

In three studies, which used different scales for progression of cataracts, there is evidence that cataracts progress over time. In the Barbados Eye Studies, individuals with pre-existing lens opacities had cumulative 9-year progression rates of 22.0% for cortical, 17.8% for nuclear, and 25.8% for PSC opacities.¹⁴ The Melbourne Visual Impairment Project reported cumulative 5-year progression rates of 14.3% for cortical, 19.3% for nuclear, and 20.0% for PSC opacities.¹⁵ In the Longitudinal Study of Cataract, individuals with pre-existing lens opacities had cumulative 5-year progression rates of 16.2% for cortical, 45.8% for nuclear, and 55.1% for PSC opacities.^{16,17}

RISK FACTORS

Numerous potential risk factors have been linked with cataract development, but many of the studies are limited in their interpretation because they did not measure cataract development or exposure to the risk factor in a standardized fashion.¹⁸ Most studies are observational and can strongly suggest an association, but they cannot prove a causative effect. Randomized controlled trials yield more robust estimates of treatment effects because of the strategies used to minimize systematic errors or bias. Studies of potential risk factors and cataract development are summarized in Tables 1 and 2.

PREVENTION

Several studies show a linkage of smoking with nuclear sclerosis and demonstrated a dose-response effect.¹⁹⁻²⁸ Findings from studies indicate a reduced risk of cataracts in past smokers compared with current smokers, demonstrating a benefit from smoking cessation.^{19,22,28,29} Cumulative lifetime exposure to ultraviolet-B radiation has been associated with lens opacities³⁰⁻³⁵; therefore, brimmed hats and ultraviolet-B blocking sunglasses are reasonable precautions to recommend to patients.³⁶

Six recent randomized controlled trials of nutritional or vitamin supplementation showed no significant effect in delaying the onset or progression of cataracts.³⁷⁻⁴² Another trial had inconclusive results because a statistically significant protective effect of supplementation with vitamin C and E and beta-carotene was found in the study arm with United States participants but

no effect was noted in the United Kingdom participants.⁴³ A trial conducted in a nutritionally deficient population in rural China did show a beneficial effect of supplementation.⁴⁴ This trial was designed as a cancer intervention study, and participants had eye examinations only at the end of the study. Because this population had chronic deficiencies of multiple nutrients, the results may not be generalizable to better-nourished populations. Table 2A summarizes the randomized controlled trials of nutrition and cataracts; Table 2B lists other studies of nutrition and cataracts. A systematic review of the literature found no benefit from multivitamin/mineral supplements in preventing cataracts.⁴⁵ Therefore, no recommendations for the use of nutritional supplements to prevent cataracts or delay progression can be made at this time.

Long-term users of inhaled or oral corticosteroids are at higher risk for cataract formation.⁴⁶⁻⁵⁰ Use of alternate medications may be a consideration for these patients.

Patients with diabetes mellitus are at higher risk for cataract formation,⁵¹⁻⁵³ and behavior modification to reduce the risk of developing type 2 diabetes may be effective.

TABLE 1 RISK FACTORS AND ASSOCIATIONS FOR CATARACTS

Cataract Type	Associated Risk Factor	Type of Study	Results
Subtypes not identified in study	Aspirin use	Randomized trials ⁵⁴⁻⁵⁷	No evidence of benefit
		Observational ⁵⁸	Increased risk
	Diabetes	Observational ^{52,53}	Increased risk
	Inhaled corticosteroid use*	Case-control ^{47,49}	Increased risk in patients aged 40 and older
		Case-control ⁵⁹	Increased risk in patients aged 70 and older
Smoking*	Observational ²⁸	Increased risk	
Cortical	Diabetes	Observational ⁵¹⁻⁵³	Increased risk
	Family history	Observational ^{31,60-62}	Increased risk
	Hypertension	Observational ⁵³	Increased risk
	Myopia (>1D)	Observational ²⁴	Increased risk
	Obesity*	Observational ^{53,63}	Increased risk
	Systemic corticosteroid use	Observational ⁴⁸	Increased risk
	Ultraviolet B light exposure*	Observational ^{30,31,35}	Increased risk
Nuclear	Diabetes	Observational ⁵³	Increased risk
	Family history	Observational ^{31,62,64,65}	Increased risk
	Smoking*	Observational ^{19,24,66}	Increased risk
	Statin use	Observational ⁶⁷	Decreased risk
	Ultraviolet B light exposure	Case-control ³⁴	Increased risk
Posterior subcapsular	Inhaled corticosteroid use*	Population-based cross-sectional ⁴⁶	Increased risk in patients aged 49 and older
	Obesity	Observational ⁶³	Increased risk
	Ocular trauma	Cross-sectional ⁶⁸	Increased risk
	Retinitis pigmentosa	Case series ⁶⁹⁻⁷¹	Increased risk
	Systemic corticosteroid use*	Observational ⁵⁰	Increased risk
Mixed	Ultraviolet B light exposure*	Observational ³⁰	Increased risk

* potentially modifiable

D = diopters

TABLE 2A SUMMARY OF RANDOMIZED CONTROLLED TRIALS OF NUTRITION AND CATARACTS

Study	Date Published	Type of Study	Sample Size	Measure	Results
Beta Carotene					
Physicians' Health Study ³⁸	2003	Randomized placebo-controlled	22,071	Supplement use	No effect of treatment on cataract development For current smokers at baseline, supplementation appeared to lessen their excess risk by about one-quarter
Women's' Health Study ⁴¹	2004	Randomized placebo-controlled	39,876	Supplement use	No effect of treatment on cataract development
Multivitamin Supplement					
Linxian Cataract ⁴⁴	1993	Randomized placebo-controlled	2,141	Supplement use	36% reduction in development of nuclear cataracts in a nutritionally deficient population
Riboflavin/Niacin					
Linxian Cataract ⁴⁴	1993	Randomized placebo-controlled	3,249	Supplement use	44% reduction in development of nuclear cataracts in a nutritionally deficient population
Vitamin C, E, and Beta Carotene					
Age-Related Eye Disease Study ³⁹	2001	Randomized placebo-controlled	4,629	Supplement use	No effect of treatment on the development or progression of cataracts
Antioxidants in Prevention of Cataracts Study ⁴²	2006	Randomized placebo-controlled	798	Supplement use	No effect of treatment on progression of cataracts
Roche European American Cataract Trial ⁴³	2002	Randomized placebo-controlled	297	Supplement use	No effect of treatment on the progression of cataracts in the United Kingdom group; small positive treatment effect in United States participants
Vitamin E and Beta Carotene					
Alpha-tocopherol, beta-carotene Cancer Prevention Study ³⁷	1997	Randomized placebo-controlled	1,828	Supplement use	No effect of treatment on the development or progression of cataracts
Vitamin E					
Vitamin E, Cataract and Age-Related Maculopathy Trial ⁴⁰	2004	Randomized placebo-controlled	1,193	Supplement use	No effect of treatment on the development or progression of cataracts

TABLE 2B SUMMARY OF OTHER STUDIES OF NUTRITION AND CATARACTS

Study	Date Published	Type of Study	Sample Size	Measure	Results
Fruit and Vegetable Intake					
Women's Health Study ⁷²	2005	Prospective cohort	35,724	Dietary intake	Reduced risk of cataracts associated with higher intakes of fruits and vegetables
Multivitamin Supplement					
Age-Related Eye Disease Study ⁷³	2006	Prospective cohort	4,590	Supplement use	Reduced risk of nuclear cataracts
Barbados Eye Study ⁷⁴	1997	Cross-sectional	4,314	Supplement use	Reduced risk of cortical cataracts
Blue Mountains Eye Study ⁷⁵	2001	Cross-sectional	2,873	Supplement use	Reduced risk of nuclear cataracts

TABLE 2B SUMMARY OF OTHER STUDIES OF NUTRITION AND CATARACTS (CONTINUED)

Study	Date Published	Type of Study	Sample Size	Measure	Results
Longitudinal Study of Cataract ⁷⁶	1998	Prospective cohort	764	Supplement use	Reduced risk of nuclear cataracts
Nurses Health Study ⁷⁷	1992	Prospective cohort	50,828	Supplement use	No association for multivitamin use and cataract extraction
Nutritional Factors in Eye Disease ⁷⁸	1994	Cross-sectional	2,152	Supplement use	Decreased risk of nuclear cataracts with supplementation; increased risk of cortical cataracts with supplementation
Physicians Health Study ⁷⁹	1994	Prospective cohort	17,744	Supplement use	Reduced risk of cataracts
Riboflavin/Niacin					
Blue Mountains Eye Study ⁸⁰	2000	Cross-sectional	2,900	Total dietary intake	Reduced risk of nuclear cataracts
Lens Opacities Case Control ²⁷	1991	Case-control	1,380	Total dietary intake	Reduced risk of any type of cataracts
Nurses Health Study ⁷⁷	1992	Prospective cohort	50,828	Total dietary intake	No association
Vitamin C					
Beaver Dam Eye Study ⁸¹	1999	Prospective cohort	1,354	Total dietary intake	No association
Blue Mountains Eye Study ⁸⁰	2000	Cross-sectional	2,900	Total dietary intake	No association
National Health and Nutrition Examination Survey II ⁸²	2000	Cross-sectional	4,001	Serum level	Reduced risk of cataracts
Nurses Health Study ⁸³	1992	Prospective cohort	50,828	Supplement use	Reduced risk of cataract extraction with 10 years or less use
Nurses Health Study ⁸¹	1997	Prospective cohort	247	Supplement use	Reduced risk of cataract extraction with more than 10 years use
Physicians Health Study ⁷⁹	1994	Prospective cohort	3,553	Supplement use	No association
Vitamin E					
Baltimore Longitudinal Study on Aging ⁸⁴	1993	Prospective cohort	660	Serum level	Inverse association with nuclear cataracts
Beaver Dam Eye Study ⁸¹	1999	Prospective cohort	1,354	Total dietary intake	No association in overall group
India-American Case Control ⁸⁵	1989	Case-control	1,441	Serum level	No association
Italian-American Case Control ⁸⁶	1991	Case-control	1,008	Serum tocopherol level	No association
Kuopio Atherosclerosis Prevention Study ⁸⁷	1996	Prospective cohort	410	Serum tocopherol level	Low serum levels associated with increased risk of progression of cataracts
Lens Opacities Case Control ⁸⁸	1991	Case-control	1,380	Serum tocopherol level	Inverse association with nuclear cataracts
Longitudinal Study of Cataract ⁷⁶	1998	Prospective cohort	764	Supplement use and serum levels	Inverse association with nuclear cataracts
National Health and Nutrition Examination Survey II ⁸²	2000	Cross-sectional	4,001	Supplement use	No association
Nurses Health Study ⁷⁷	1992	Prospective cohort	50,828	Total dietary intake and supplement	No association

TABLE 2B SUMMARY OF OTHER STUDIES OF NUTRITION AND CATARACTS (CONTINUED)

Study	Date Published	Type of Study	Sample Size	Measure	Results
Nutritional Factors in Eye Disease Study ⁸⁹	1999	Prospective cohort	400	Serum tocopherol level	Inverse association with nuclear cataracts
Physicians Health Study ⁷⁹	1994	Prospective cohort	3,533	Supplement use	No association
Vitamin E, Cataract and Age-Related Maculopathy Trial ⁹⁰	2000	Cross-sectional	1,111	Supplement use	Inverse association with cortical cataracts

RATE OF CATARACT SURGERY IN THE UNITED STATES

In 2004, a total of 1.8 million cataract procedures were performed on Medicare beneficiaries who were not enrolled in health maintenance organizations. In 2004, the national average surgeon reimbursement was \$684.39 for a national total of \$1.2 billion. Other associated costs are facility fees, including intraocular lens (IOL) implant costs, and anesthesia services. Cataract surgery with IOL implantation was the most frequently performed operation and the single largest expenditure for any Part B procedure in the Medicare program, calculated by Part B procedure codes based on allowed charges.⁹¹ For the period January 1, 1995, to December 31, 2002, a longitudinal study estimated that the annual rate of cataract surgery was 5.3%.⁹² When assessed across populations residing in different states or metropolitan areas, there is some variation in the rate of cataract surgery, but it is relatively low compared with geographic variations observed in other surgical procedures. In one study, factors associated with a higher rate of cataract surgery were female gender, living in a more southerly latitude, a higher concentration of optometrists in a specific geographic area, and a higher allowed charge for cataract surgery.⁹³ A higher concentration of ophthalmologists was not associated with a higher rate of cataract surgery. A decreased likelihood of undergoing cataract surgery was reported among African American Medicare beneficiaries when compared with Caucasian Americans.⁹³

The utilization of cataract surgery in the United States has been found to be appropriate for the majority of cases studied. A study at ten academic medical centers found that 2% of cataract surgeries performed were classified as inappropriate based on available records.⁹⁴ An inappropriate rating meant that the risks of surgery were deemed to exceed the potential benefits as rated by a panel. The percentage deemed inappropriate in this study correlates to earlier estimates of 2.5% by the 1993 US General Accounting Office and a rate of 1.7% by the US Inspector General.⁹⁴ Cataract appropriateness ratings are comparable to the rate found for coronary artery bypass graft surgery (2.4% inappropriate) and lower than the rate for carotid endarterectomies (10.6% inappropriate).^{95,96} The criteria for appropriateness of cataract surgery were based on indicators of visual acuity and functional impairment, such as difficulty driving, reading, and other activities of daily living. The study did note that the information that was recorded varied, particularly on functional impairment, and increased attention to documenting specific functional impairments is appropriate. A study of Medicare beneficiaries in 13 large areas in the United States found that cataract surgery ranked among procedures with the least variation in use.⁹⁷ Also, second opinion programs implemented for cataract surgery have not succeeded because initial recommendations for surgery were found to be appropriate. The validity of the appropriateness methodology used to evaluate the utilization of cataract surgery was supported by a study of the association between the appropriateness rating and postoperative visual acuity.⁹⁸ For a sample of 768 patients, 89% of those who had surgeries rated as appropriate were found to have a visual acuity improvement of at least two lines postoperatively. For the group that had surgeries rated as inappropriate, 36% had a visual acuity improvement of at least two lines postoperatively.

VISUAL FUNCTION AND QUALITY OF LIFE

The multiple components of visual function include central near, intermediate, and distance visual acuity; peripheral vision; visual search; binocular vision; depth perception; contrast sensitivity; perception of color; adaptation; and visual processing speed.^{99,100} Visual function also can be

measured in terms of functional disability caused by visual impairment.¹⁰¹ Many activities are affected by more than one of these visual components.

Function and quality of life are the outcomes of treatment that are most critical and applicable to the patient. In well-designed observational studies, cataract surgery consistently has been shown to have a significant impact on vision-dependent function; up to 90% of patients undergoing first-eye cataract surgery note improvement in functional status and satisfaction with vision.¹⁰²⁻¹⁰⁵ Several studies have reported an association between improved visual function after cataract surgery and an improved health-related quality of life.^{99,103,106-108} Visual function plays an important role in physical function and well-being,¹⁰⁹⁻¹¹² particularly in terms of mobility.¹¹³ The loss of visual function in the elderly is associated with a decline in physical and mental functioning as well as in independence in activities of daily living,^{114,115} including night-time driving, daytime driving, community activities, and home activities.

Visual impairment is an important risk factor for falls¹¹⁶ and for hip fracture;¹¹⁷ poor depth perception and decreased contrast sensitivity has been found to increase independently the risk of hip fracture.¹¹⁸ In a randomized controlled trial, first-eye cataract surgery was found to reduce the rate of falling and fracture over a 12-month period.¹⁰⁸ Visual impairment, in particular a decrease of visual acuity and contrast sensitivity, has been shown to be associated with difficulties in driving.^{119,120} Drivers with visually significant cataracts were 2.5 times more likely to have had an at-fault involvement in a motor vehicle crash over a 5-year period compared with drivers without cataracts.¹²¹ When older adults with cataracts who have undergone surgery are compared with those who did not undergo surgery, motor vehicle crash rates in the 4 to 6 years of follow-up were halved in the surgery group.¹²²

The quality-adjusted life year (QALY) is a generic outcome measure that was developed to compare the cost-utility of different health care interventions.¹²³ A lower dollar cost per QALY indicates a better value (see Appendix 2). Using Swedish registry data, the hypothetical cost per QALY gained (calculated in 2002) for cataract extraction in one eye was estimated at US \$4,500.¹²⁴ Studies in the United States found that the cost per QALY gained for cataract extraction in the first eye was \$2,023¹²⁵ (calculated in 2002) and in the second eye was US \$2,727 (calculated in 2003).¹²⁶ The value of cataract surgery compares favorably with that reported for other ophthalmic (e.g., laser photocoagulation for diabetic macular edema, \$3,101¹²⁷; laser photocoagulation for extrafoveal choroidal neovascularization, \$23,640¹²⁸) and non-ophthalmic procedures (e.g., single-vessel coronary artery bypass surgery for disease of the left anterior descending artery costs \$7,000/QALY¹²⁷) and demonstrate the value of cataract surgery.

In summary, these studies show that physical function, emotional well-being, safety, and overall quality of life can be enhanced when visual function is restored by cataract extraction.

Improved visual function as a result of cataract surgery includes the following:

- ◆ Better optically corrected vision.
- ◆ Better uncorrected vision with reduced spectacle dependence.
- ◆ Increased ability to read or do near work.
- ◆ Reduced glare.
- ◆ Improved ability to function in dim levels of light.
- ◆ Improved depth perception and binocular vision.
- ◆ Improved color vision.

Improved physical function as a critical outcome of cataract surgery includes the following:

- ◆ Increased ability to perform activities of daily living.
- ◆ Increased opportunity to continue or resume an occupation.
- ◆ Increased mobility (walking, driving).

Improved mental health and emotional well-being as a second critical outcome of cataract surgery includes the following benefits:

- ◆ Improved self-esteem and independence.
- ◆ Increased ability to avoid injury.
- ◆ Increased social contact and ability to participate in social activities.
- ◆ Relief from fear of blindness.



CARE PROCESS

PATIENT OUTCOME CRITERIA

Outcome criteria can vary for each patient, depending on the patient's needs, lifestyle, and medical condition. In general, outcome criteria include the following:

- ◆ Reduction of visual symptoms.
- ◆ Improvement in visual function.
- ◆ Achievement of desired refractive outcome.
- ◆ Improvement in quality of life.

DIAGNOSIS

The purpose of the comprehensive evaluation of a patient whose chief complaint might be related to a cataract is to determine the presence of a cataract, confirm that a cataract is a significant factor related to the visual impairment and symptoms described by the patient, and exclude or identify other ocular or systemic conditions that might contribute to visual impairment or affect the cataract surgical plan or ultimate outcome.

Evaluation of Visual Impairment

The impact of a cataract on visual function can be assessed by self-reported functional status or difficulty with vision. The latter may be measured by tests of contrast sensitivity, glare disability, or visual acuity. Over time, patients adapt to their visual impairment and may fail to notice functional decline that accompanies the insidious progression of a cataract. There is no single test that adequately describes the effect of a cataract on a patient's visual status or functional ability. Similarly, no single test defines the threshold for performing cataract surgery. Preoperative visual acuity is a poor predictor of postoperative functional improvement; therefore, the decision to recommend cataract surgery should not be made on the basis of visual acuity alone.^{102,129 [A:II]}

Studies have indicated that measures of functional impairment related to vision provide valid and reliable information that is not reflected in the measurement of visual acuity.^{130,131} For example, visual functional status indices such as the Activities of Daily Vision Scale (ADVS) and the Visual Function Index (VF-14) have been shown to correlate more strongly with functional improvement and satisfaction with vision after cataract surgery than does Snellen visual acuity.¹⁰¹

Two main categories of validated questionnaires for measuring function exist: those that measure general health status (e.g., Short Form-36¹³² and Sickness Impact Profile¹³³) and those that are vision-specific measures. Questionnaires that measure general health status are less strongly correlated with improvement following cataract surgery than are disease-specific measures.¹³⁴ Vision-specific instruments developed for cataracts include one by Bernth-Peterson,¹³⁵ the Visual Activities Questionnaire,¹⁰⁰ the ADVS,¹³⁰ the VF-14,¹⁰¹ and the National Eye Institute Visual Function Questionnaire (NEI-VFQ).^{136,137} These questionnaires provide a standardized approach to assess the patient's function, which can be analyzed and compared across time periods and populations. Questionnaires used alone are not intended to be the basis for determining the need for surgery. They contribute to the overall evaluation of a patient who has a cataract and may aid in the therapeutic decision-making process. However, at this time there is no universally accepted standard for assessing functional impairment related to vision. The assessment of functional status is a pertinent part of the patient's history. The patient should be asked specifically about near and distant vision under varied lighting conditions for activities that the patient views as important.^[A:III]

Ophthalmic Evaluation

The comprehensive evaluation (history and physical examination) includes those components of the comprehensive adult medical eye evaluation¹³⁸ specifically relevant to the diagnosis and treatment of a cataract as listed below.

- ◆ Patient history,^[A:III] including the patient's assessment of functional status, pertinent medical conditions, medications currently used, and other risk factors that can affect the surgical plan or outcome of surgery (e.g., immunosuppressive conditions, sympathetic alpha-1a antagonists).
- ◆ Visual acuity with current correction (the power of the present correction recorded) at distance and when appropriate at near.^[A:III]
- ◆ Measurement of best-corrected visual acuity (with refraction when indicated).^[A:III]
- ◆ External examination (lids, lashes, lacrimal apparatus, orbit).^[A:III]
- ◆ Examination of ocular alignment and motility.^[A:III]
- ◆ Assessment of pupillary function.^[A:III]
- ◆ Measurement of intraocular pressure (IOP).^[A:III]
- ◆ Slit-lamp biomicroscopy of the anterior segment.^[A:III]
- ◆ Dilated examination of the lens, macula, peripheral retina, optic nerve, and vitreous.^[A:III]
- ◆ Assessment of relevant aspects of the patient's mental and physical status.^[B:III]

Supplemental Ophthalmic Testing

Supplemental preoperative ophthalmic tests are not specific for a cataract but may help to elucidate better the cause of an individual's visual symptoms and the extent to which comorbidities are contributing to these symptoms. In a large majority of patients, the ophthalmologist is able to determine that the cataract is responsible for the patient's visual loss by examining the patient and correlating the findings with the patient's specific symptoms.

Occasionally, however, a patient presents with visual symptoms that appear to be disproportionate to the degree of cataract formation. Visual acuity testing does not measure certain visual symptoms, such as glare disabilities and reduced contrast sensitivity.^{135,139-142} In addition, measurements taken in a darkened examination lane may significantly underestimate the functional problems experienced in environments with varied lighting conditions. Therefore, supplemental testing directed toward these problems can help to better assess and quantify functional visual impairment due to a cataract. Glare testing determines the degree of visual impairment caused by the presence of a light source located in the patient's visual field. Cataracts may cause severe visual disability in brightly lit situations such as ambient daylight or from oncoming auto headlights at night. Visual acuity in some patients with cataracts is normal or near normal when tested in a dark examination room, but when these patients are retested using a source of glare, visual acuity (or contrast sensitivity) drops precipitously.¹⁴³

Contrast sensitivity testing measures the eye's ability to detect subtle variations in shading by using figures that vary in contrast, luminance, and spatial frequency. It is a more comprehensive measure of visual function than visual acuity, which determines perception of high-contrast letters or numbers. In the patient who complains of visual loss and has lens changes, contrast sensitivity testing may demonstrate a significant loss of visual function not appreciated in testing of visual acuity.^{139-142,144,145} Decreased contrast sensitivity (as well as decreased visual acuity) may occur for a number of reasons, and this test is, therefore, not a specific indicator of visual loss due to a cataract. In spite of substantial progress over the past few years, there is no standard or universally preferred method for testing contrast sensitivity.

Ocular wavefront testing has demonstrated that even mild degrees of cataracts may be associated with a significant increase in lower and higher order visual aberrations. The crystalline lens can contribute either net positive or negative spherical aberration, depending on the cataract type. This may explain the symptoms reported by some individuals with mild lens opacity and reasonably good visual acuity.

Other supplemental tests attempt to differentiate between a cataract and ocular comorbidities as the cause of visual impairment. Potential acuity tests attempt to predict the visual acuity that will be obtained following cataract surgery. Subjective potential acuity tests require the patient to respond to questions about visual stimuli presented and can be divided into two categories. The

Guyton-Minkowski Potential Acuity Meter, laser interferometer, and scanning laser ophthalmoscope¹⁴⁶ project an image onto the retina through relatively clear regions of the lens. Other tests such as the Retinal Acuity Meter (formerly the Illuminated Near Card) and potential acuity pinhole require the patient to read a brightly illuminated near card through a trial frame that combines their near spectacle correction with a pinhole.¹⁴⁷⁻¹⁵⁰ The near-card pinhole methods are simpler and less expensive and appear to be as accurate as the technology-dependent Guyton-Minkowski Potential Acuity Meter and scanning laser ophthalmoscope.^{147,148} Objective potential acuity tests (electroretinography, visual evoked potential) electronically measure the response to visual stimuli presented. Potential acuity tests are most accurate with mild to moderate cataracts and normal macular function. Unfortunately, all of these tests perform less reliably in the presence of dense cataracts or macular pathology.^{147,149,151,152}

The biomicroscopic and ophthalmoscopic examination of the macular region do not necessarily predict macular function when the macula is abnormal. Potential acuity testing may contribute helpful adjunct information in these situations.^{147,153}

Specular microscopy and corneal pachymetry have been used in patients with known preoperative corneal disease to help determine whether the cornea is likely to remain clear following cataract surgery. These tests are generally not needed, but they may be useful in eyes in which the corneal endothelial function is suspected to be abnormal as a result of endothelial corneal dystrophies, previous ocular surgery, or trauma, for example. However, several studies suggest that specular microscopy has low accuracy in predicting whether the cornea will remain clear following cataract surgery.^{154,155}

Additional specialized preoperative evaluations may provide valuable information in selected cases but are not routinely necessary. Corneal topography and rigid contact lens overrefraction are useful when irregular astigmatism is suspected to be contributing to visual impairment. Additionally, corneal topography is used when high astigmatism is present and corrective surgery is contemplated concurrently with cataract surgery. Fluorescein angiography is occasionally helpful in the presence of mild to moderate cataracts when the ophthalmologist suspects conditions such as diabetic or inflammatory macular edema, or submacular neovascularization. Unlike fluorescein angiography, optical coherence tomography can diagnose subtle macular pathology even in the presence of significant media opacity. B-scan ultrasonography is appropriate when the cataract inhibits adequate fundus visualization. Visual fields, external and fundus photography, and special color vision testing have not been shown to be of value in routinely evaluating patients before cataract surgery.

MANAGEMENT

Nonsurgical Management

Management of a visually significant cataract is primarily surgical. Nonsurgical management includes counseling patients about cataract-related visual symptoms, providing reassurance about the cause of the visual disability, and prescribing new eyeglasses where appropriate. For some patients with a clinically significant cataract, a change in spectacle correction or use of specialized tints may restore acceptable vision for daily activities. In rare cases, the optical advantage of dilating a pupil of a patient with a small central cataract may outweigh the risk of glare problems that are induced by the dilating agent.¹⁵⁶

At the present time, the highest quality evidence does not support a benefit from nutritional supplementation in preventing or delaying progression of cataracts; therefore, treatment with supplements is not recommended (see tables 2A and 2B).^{45 [A:1]} Currently, there are no pharmacological treatments known to eliminate existing cataracts or retard their progression.

Patients may reduce their risk of cataract development or progression by modifying their exposure to risk factors. Patients who are currently smoking should be informed of the increased risk of cataract progression and the benefits of smoking cessation in retarding the progression of cataracts that have been demonstrated in several studies.^{20-22 [A:III]} Studies have found that smokers report that a physician's advice to quit is an important motivator in attempting to stop smoking.¹⁵⁷⁻¹⁶⁰

Patients who are long-term users of oral or inhaled corticosteroids should be informed of the increased risk of cataract formation^{47-50,59 [A:III]} and may wish to discuss alternate medications with

their primary care physician. Patients with diabetes mellitus should be informed of their increased risk of cataract formation.^{51-53 [A:II]} Brimmed hats and ultraviolet-B blocking sunglasses are reasonable precautions to recommend to patients.³⁶

Surgical Management

Indications for Surgery

- ◆ The primary indication for surgery is visual function that no longer meets the patient's needs and for which cataract surgery provides a reasonable likelihood of improved vision.^[A:III]
- ◆ Other indications for a cataract removal include the following:
 - ◆ Clinically significant anisometropia in the presence of a cataract.^[A:III]
 - ◆ The lens opacity interferes with optimal diagnosis or management of posterior segment conditions.^[A:III]
 - ◆ The lens causes inflammation (phacolysis, phacoanaphylaxis).^[A:III]
 - ◆ The lens induces angle closure (phacomorphic or phacotopic).^[A:III]

Contraindications to Surgery

Surgery for a visually impairing cataract should not be performed under the following circumstances:^[A:III]

- ◆ Eyeglasses or visual aids provide vision that meets the patient's needs.
- ◆ Surgery will not improve visual function.
- ◆ The patient cannot safely undergo surgery because of coexisting medical or ocular conditions.
- ◆ Appropriate postoperative care cannot be arranged.

Preoperative Medical Evaluation

The ophthalmologist who is to perform the cataract surgery has the following responsibilities:

- ◆ To examine the patient preoperatively (see Ophthalmic Evaluation).^[A:III]
- ◆ To ensure that the evaluation accurately documents the symptoms, findings, and indications for treatment.^[A:III]
- ◆ To obtain informed consent from the patient or the patient's surrogate decision maker after discussing the risks, benefits, and expected outcomes of surgery, including anticipated refractive outcome and the surgical experience.^[A:III]
- ◆ To review the results of presurgical and diagnostic evaluations with the patient or the patient's surrogate decision maker.^[A:III]
- ◆ To formulate a surgical plan, including selection of an appropriate IOL.^[A:III]
- ◆ To formulate postoperative care plans and inform the patient or the patient's surrogate decision maker of these arrangements (setting of care, individuals who will provide care).^[A:III]
- ◆ To afford the patient or the patient's surrogate decision maker the opportunity to discuss the costs associated with surgery.^[B:III]

The best interest of the patient is served by having the operating ophthalmologist perform the preoperative evaluation, because this will allow the surgeon to formulate the surgical plan and to establish a relationship with the patient prior to surgery. Patients feel more comfortable and reassured knowing and meeting the ophthalmologist performing the surgery. Although the ophthalmologist is responsible for the examination and reviewing the data, certain aspects of data collection may be conducted by another trained individual under the ophthalmologist's supervision and with his or her review.¹⁶¹

All patients undergoing cataract surgery should have a history and physical examination relevant to the risk factors for undergoing the planned anesthesia and sedation and as directed by a review of systems.^[A:III] For patients with certain severe systemic diseases (e.g., chronic obstructive pulmonary disease, recent myocardial infarction, unstable angina, poorly controlled diabetes, or poorly controlled blood pressure) a preoperative medical evaluation by the patient's physician should be strongly considered.^{162 [A:II]}

Laboratory testing as indicated by the findings in the history and physical examination is appropriate.^{163 [A:I]} The Study of Medical Testing for Cataract Surgery demonstrated that perioperative morbidity and mortality were not decreased by the use of routine medical testing.¹⁶³

Biometry and Intraocular Lens Power Calculation

Achieving the targeted postoperative refraction requires measuring axial length accurately, determining corneal power, and using the most appropriate IOL power formula. The axial length can be measured by A-scan ultrasonography using either an applanation (contact) or an immersion (noncontact) technique. Because the applanation probe can compress the cornea, resulting in artificial shortening of the axial length, the accuracy of this method is more dependent on the skill and experience of the operator.¹⁶⁴⁻¹⁶⁶

Partial coherence interferometry is a noncontact method to measure axial length that uses optical rather than ultrasound technology. It is comparable to immersion A-scan biometry in terms of accuracy and consistency^{167,168} and more accurate than contact A-scan biometry.^{164,169,170} Its advantages include ease and speed of automated operation and the ability to determine and measure to the point of fixation. Because of the latter feature this method is more accurate than ultrasound when the fovea is located on the slope of a staphyloma.¹⁷¹ Additionally, partial coherence interferometry is more useful than ultrasound when the patient has silicone oil in the posterior segment.¹⁷² However, because this optical method of biometry is unable to measure accurately through certain cataracts or when patients are unable to fixate properly, A-scan biometry is required to measure the axial length in these eyes.^{173,174 [A:III]} Biometry measurement for both eyes is advisable, even if surgery is not planned for the other eye.

Formulas for calculating IOL power rely on keratometry to determine the net refractive contribution of the cornea. These measurements can be obtained through either manual or automated keratometry, or through corneal topography. Following keratorefractive surgery, determination of central corneal power is particularly difficult (see Cataract Surgery Following Refractive Surgery section). Current keratometers are unable to measure accurately the central corneal power following keratorefractive surgery. The use of standard keratometry measured values without a compensatory adjustment will usually result in an unexpected postoperative refraction for these eyes.

Latest generation lens calculation formulas such as Haigis, Hoffer Q, Holladay, Olsen, and SRK/T should be used in the IOL selection process.^{175-179 [A:III]} Some formulas incorporate additional measurements such as corneal diameter and anterior chamber depth. All of these formulas rely on a numerical constant that should correlate with the chosen IOL's predicted effective lens position within the eye. This constant varies according to the IOL design and therefore is specific to each individual IOL model. Although the lens manufacturer supplies this value, there are methods available to customize further this numerical constant based on an individual surgeon's actual refractive outcome data for each particular lens.

The surgeon should consider the patient's individual desires and needs in selecting an appropriate postoperative refractive target.^[A:III] Depending on the manufacturer, extended ranges of both high plus and high minus IOL powers are available. For the rare patient requiring an IOL power in excess of the available range, piggybacking of two posterior chamber IOLs has been used.¹⁸⁰ Intraocular lens power calculations for piggybacked IOLs may be less accurate because it is difficult to predict the effective lens position. Although refractive results with piggybacking IOLs have been favorable in two small case series,^{181,182} consideration must be given and patients counseled about the development of interlenticular (between the IOLs) membrane formation.^{183,184 [A:III]}

Anesthesia

Cataract surgery may be performed using a variety of anesthesia techniques that include general and local (regional) anesthesia (e.g., retrobulbar, peribulbar, periocular, sub-Tenons injection, topical, and intracameral), as well as no anesthesia.¹⁸⁵ The planned mode of anesthesia should be discussed with the patient so that she or he will know what to expect in terms of pain, discomfort, consciousness level, visual experiences, and complications.^[A:III] The outcomes of cataract surgery measured in terms of visual acuity, functional impairment, complications, adverse medical events,

and patient satisfaction have not been shown to vary significantly among anesthesia techniques.¹⁸⁶⁻¹⁸⁸

Local (regional) anesthesia is generally used, with or without sedation/analgesia. General anesthesia may be utilized if needed for those patients with medical, psychosocial, or surgical indications. Deep sedation may carry a higher risk of intraoperative respiratory compromise. In a review of 195 studies on cataract surgery using local anesthesia, the investigators concluded that a variety of anesthesia strategies for cataract surgery are safe and effective and that they provide good or excellent intraoperative pain control.^{186,189}

Anesthesia techniques with needle injection may be associated with complications such as strabismus, globe perforation, retrobulbar hemorrhage, and macular infarction not seen with topical, blunt cannula, and other non-needle injection techniques.^{186,189} Many patients who have cataract surgery under regional anesthesia experience a variety of visual sensations such as seeing lights, colors, flashes, movement of instruments, and the surgeon's hand or fingers. Three percent to 16% of patients were frightened by their intraoperative visual experience.¹⁹⁰⁻¹⁹⁴ Appropriate preoperative counseling about this phenomenon may make it less frightening to the patient.¹⁹⁴

In the 2005 Learning Survey (16% response rate with 743 responses), 48% of ophthalmologists who performed cataract surgery preferred using topical anesthesia with intracameral lidocaine.^{195,196} The questionnaire in this report was sent to US members of the American Society of Cataract and Refractive Surgery (ASCRS), not to all ophthalmologists who perform cataract surgery. Intracameral lidocaine injection has been reported to be safe in various studies but variably effective.¹⁹⁷⁻²⁰⁰

Intravenous (IV) access is generally recommended to treat potential side effects when anxiolytics are administered.^{201 [A:III]} However, given the trend toward topical anesthesia and reduction or elimination of intravenous analgesia/sedation, IV access may not be routinely necessary.

Monitoring during administration of anesthesia and surgery should include electrocardiogram, pulse oximetry, blood pressure, and respirations. These should be performed by personnel (other than the operating ophthalmologist) qualified to monitor and manage the patient's status.^{202 [A:III]}

One study found that a patient's medical history, laboratory values, and electrocardiogram were not predictive of the need for intervention by anesthesia personnel, and intervention was required in 37% of all cataract cases.²⁰³ However, this study, in which all patients received a peribulbar block, did not document that any of the interventions by anesthesia personnel affected cataract surgery outcomes. In another study, monitored anesthesia care for 1,957 cataract surgery cases was provided by registered respiratory practitioners who were trained as anesthesia assistants and who used topical anesthesia with or without IV sedation. Anesthesiologist intervention was required in 4% of the cases.²⁰²

The review of cataract surgery studies using local anesthesia found weak evidence to support the benefits of IV or intramuscular sedation or analgesia to improve pain relief, anxiety, or patient satisfaction.¹⁸⁶ The evidence was insufficient to determine if any analgesic or sedation regimen was better than any other. The supplemental report from the Study of Medical Testing for Cataract Surgery showed that patients experienced more postoperative drowsiness and nausea when IV agents were used and that nausea and vomiting increased significantly with the number of agents (opioid, sedative, hypnotic, diphenhydramine) used.¹⁸⁷ In another report from the same study, the investigators found that the use of IV sedatives during cataract surgery was associated with increased risk of an adverse intraoperative medical event.¹⁸⁸ In addition, the risk of an adverse intraoperative medical event was increased when IV opiates and sedatives were both used.¹⁸⁸ Some studies have reported that oral anxiolytic medications decrease anxiety levels^{204,205} and induce amnesia²⁰⁴⁻²⁰⁷ when given to patients before cataract surgery, but another trial found that there was no difference between the treatment and control group in reported anxiety levels.²⁰⁸

In summary, given the lack of evidence for an optimal anesthesia strategy during cataract surgery, the type of anesthesia management should be determined by the patient's needs and the preferences of the patient and surgeon.^{186 [A:II]}

Infection Prophylaxis

Owing to the potentially severe consequences of endophthalmitis, prevention remains of great concern. However, controlled studies of endophthalmitis prophylaxis have been difficult to perform due to the low incidence of endophthalmitis, varied practice patterns, inconsistent definitions, and the rapid evolution of surgical techniques.

Until recently the accepted incidence of sporadic endophthalmitis has been between 0.5 and 1 case per thousand of routine cataract procedures. However, since 1994 an increased rate of post-cataract surgery infections has been reported, while the incidence of infection after other anterior segment procedures has been on the decline.²⁰⁹⁻²¹¹ It has been proposed that the increased infection rates correspond to the increased use of clear corneal incisions for cataract surgery, because improperly constructed clear corneal cataract incisions are more prone to postoperative instability, leakage, and a potential influx of microbes than are sclerocorneal incisions.²¹²⁻²¹⁸ On the other hand, two large case series found no greater likelihood of infection with corneal versus other types of incisions.^{219,220} Nevertheless, careful watertight incision construction and closure (with or without sutures) is mandatory, irrespective of surgical style, because the incidence of infection increases with wound leak.^{221 [A:III]} Other factors associated with increased rates of endophthalmitis include intraoperative rupture of the posterior capsule, vitreous loss, prolonged surgery, immunodeficiency, active blepharitis, and lacrimal duct obstruction.²²²⁻²²⁴

Regarding the relationship of the IOL to the likelihood for infection, it appears that optic material may not influence the rate of infection.²¹⁴ However, polypropylene loop supports have been associated with a greater chance for infection, because it appears that bacterial adherence to polypropylene exceeds that for other materials.²²⁵ As a corollary, it has been demonstrated that antibiotics reduce the tendency for microorganisms to adhere to the surface of IOLs.^{226,227} Also, there has been concern that there is a greater chance for IOL-related contamination of the anterior chamber when the lens comes in contact with the ocular surface prior to implantation. On the other hand, when the IOL is folded into an inserting tube and is placed within the eye directly through the tube, avoiding the ocular surface, likelihood for intraocular contamination is reduced.²²⁸

While very occasional clusters of infections may be induced by contaminated surgical products²²⁹⁻²³² or contaminated operating room environments,^{233,234} it has been established that the patient's periocular flora is the source of the microbes responsible for most cases of sporadic postoperative infection.²³⁵ Presumably the risk for endophthalmitis can be lessened by reducing the number of microbes on the ocular surface, by reducing the opportunity for microbes to reach the intraocular environment during or after surgery, or by eliminating those organisms that may have reached the eye intra- or postoperatively.

In accord with those concepts, prophylactic strategies that have been employed include using topical antibiotic eye drops before surgery, applying 5% povidone iodine to the conjunctival cul de sac, preparing the periocular skin with 10% povidone iodine, careful sterile draping of the eyelid margins and eyelashes, adding antibiotics to the irrigating solution, instilling intracameral antibiotics at the close of surgery, injecting subconjunctival antibiotics, and applying topical antibiotic eye drops after surgery. A nonrandomized controlled trial has provided evidence that using topical 5% povidone iodine in the conjunctival cul de sac reduced the incidence of postoperative infection.^{236,237} Lower concentrations of povidone iodine are less effective in reducing conjunctival bacterial colony counts.²³⁸ Systemic antibiotics are rarely used; however, it has been shown that certain fluoroquinolone antibiotics penetrate the blood/ocular barrier adequately to reach levels above the minimum inhibitory concentrations for many organisms inside the eye.²³⁹⁻²⁴¹

Although still controversial, there is increasing evidence that supports the use of intraocular antibiotics to reduce the risk of endophthalmitis. A preliminary report from a partially masked, randomized, placebo-controlled multinational clinical study has been released, and complete results are pending.²⁴² The European Society of Cataract and Refractive Surgeons study of the prophylactic effect of intracameral cefuroxime injection at the conclusion of the procedure and/or perioperative levofloxacin eye drops on the incidence of endophthalmitis after phacoemulsification was halted early because of results of a beneficial effect of intracameral cefuroxime. With data from 13,698 patients with complete follow-up records, investigators found that the odds ratio for developing endophthalmitis was 4.59 (95% CI, 1.74-12.08; $P=0.002$) in the

group not receiving intracameral cefuroxime injection. However, the incidence of endophthalmitis in the control group was approximately three times higher than that reported in most other studies from US centers. This raises the question of whether the results can be generalized to a US population. An earlier retrospective study in Sweden reported efficacy of intracameral cefuroxime, a second generation cephalosporin, in reducing post-cataract endophthalmitis.²⁴³ Two retrospective studies in Spain have reported that intracameral injection of cefazolin, a first generation cephalosporin, reduced post-cataract endophthalmitis.^{244,245}

Evidence of the benefit of injecting subconjunctival antibiotics at the close of surgery is inconclusive and is associated with risks that include intraocular toxicity with the potential for macular infarction when aminoglycosides are used.²⁴⁶

In summary, use of a 5% solution of povidone iodine in the conjunctival cul de sac is recommended to prevent infection.^{237,247 [A:II]} Given the absence of clear evidence about the benefit of other prophylactic measures, it is up to the ophthalmologist to decide on the use of any particular strategy in addition to povidone iodine in the perioperative period. Nevertheless, it is incumbent on the surgeon to assure that all incisions are closed in a watertight fashion at the end of the procedure.^{221 [A:III]}

Toxic anterior segment syndrome (TASS) is a noninfectious inflammatory disease with symptoms and signs that mimic infection. A variety of factors that may cause TASS have been described²⁴⁸ and outbreaks may occur in a cluster at a specific surgical center. Investigations of TASS outbreaks and ways to prevent them are underway.²⁴⁹

Surgical Techniques

The preferred method to remove a cataract is extracapsular extraction, most commonly by phacoemulsification, which is now used in over 90% of cataract surgeries performed in the United States. The 2005 Learning Survey highlighted the predominant trend of the small-incision, phacoemulsification technique.¹⁹⁶ The findings were that many respondents use topical anesthesia with intracameral lidocaine, clear-corneal incisions, and a no-suture technique.

In a randomized trial of extracapsular cataract extraction (ECCE) and small-incision phacoemulsification, visual acuity following phacoemulsification was significantly better and more stable during the 1-year postoperative follow-up period compared with larger incision non-phaco techniques (ECCE). There were fewer surgical complications in the phacoemulsification group.²⁵⁰ At 1 year, the incidence of posterior capsular opacification (PCO) was significantly higher in the ECCE group than in the phacoemulsification group.²⁵⁰ Other nonultrasonic methods to remove the nucleus through a small incision, such as laser, mechanical, or high frequency water pulse technology, have been developed and are evolving.^{251,252}

The ideal technical elements of a successful cataract procedure currently include the following:

- ◆ Capsular bag fixation of an appropriate posterior chamber IOL.
- ◆ Minimal or no trauma to the corneal endothelium, iris, and other ocular tissues.
- ◆ A secure, watertight incision that minimizes surgically-induced astigmatism or reduces pre-existing corneal astigmatism.

Intraocular steps that are commonly used during phacoemulsification include the following:

- ◆ Construction of an appropriately sized incision that is tight enough to achieve a fluidically stable anterior chamber.
- ◆ Use of an ophthalmic viscosurgical device (OVD) to protect the corneal endothelium, manipulate tissues, and maintain adequate working space during surgery.
- ◆ Capsulorrhexis.²⁵³ This is a continuous curvilinear capsulotomy that facilitates hydrodissection, prevents posterior capsule tears that originate from radial anterior capsule tears, and facilitates the implantation and fixation of the IOL within the capsular bag. A capsulorrhexis that completely overlaps the IOL edge impedes the development of PCO.
- ◆ Hydrodissection,²⁵⁴ which reduces zonular stress during phacoemulsification by mobilizing the nucleus and epinucleus. By facilitating thorough cortical aspiration, hydrodissection also helps to retard PCO.²⁵⁵
- ◆ Nuclear disassembly and emulsification using techniques such as divide and conquer²⁵⁶ or chopping²⁵⁷ to minimize surgical trauma to intraocular tissues.

- ◆ Thorough removal of remaining epinucleus and cortex.
- ◆ Implantation and centration of a small-incision IOL within the capsular bag, or as dictated by surgical events, secure fixation of the IOL in the ciliary sulcus (with or without sutures) or anterior chamber.
- ◆ Removal of the OVD to minimize postoperative IOP elevation.
- ◆ Assurance of a watertight incision using sutures if the incision size and architecture alone do not produce a secure, self-sealing wound.

Incision location, size, and design may depend on several factors, including the patient's orbital anatomy, the type of IOL to be implanted, the role of the incision in astigmatism management, and surgeon preference and experience. For example, varying the incision characteristics and centering it on the steep corneal meridian may reduce pre-existing astigmatism.²⁵⁸

When feasible, small-incision surgery is generally preferred for a number of reasons.^{259 [A:I]} Smaller incisions are amenable to self-sealing wound construction so that fewer or no sutures are needed for secure closure. They are therefore inherently safer in the event of sudden patient movement or a suprachoroidal hemorrhage during surgery. They may be associated with less initial postoperative inflammation.^{260,261} Finally, smaller incisions induce less unwanted astigmatic change than larger incisions^{259,262-265} and result in earlier and greater long-term stability of the refraction.

Intraocular Lenses

Intraocular lens implantation is the method of choice to correct aphakia optically, unless there are specific contraindications.^[A:III] While posterior chamber lenses are the most frequently used implants, an anterior chamber lens is occasionally necessary when no capsular support is available.

Cataract surgeons can choose from a wide variety of posterior chamber lens styles and materials to find the appropriate one for their patients' needs. Lens optic size and shape, optic and haptic configuration, optic edge design, and optic and haptic materials,^{266,267} and chromophore content are engineered to give different lenses a variety of characteristics.

Intraocular lenses fabricated from polymethyl methacrylate (PMMA), which are nonfoldable, were most frequently used before foldable IOLs. Foldable IOLs are now the most common choice following phacoemulsification because of their ability to be implanted through smaller incisions. Foldable IOLs can be classified according to their optic material: silicone; hydrophilic acrylic, hydrophobic acrylic; and collagen/hydroxy ethyl methacrylate [HEMA]-copolymer-based. Most IOLs have ultraviolet-blocking chromophores. The material and design of each lens and its insertion system is associated with its own unique set of positive and negative attributes. It is therefore incumbent upon each surgeon to have an understanding of these varied lenses and their inserting systems.^[A:III]

Currently, the most popular foldable IOL materials are hydrophobic acrylic and silicone.²⁶⁸ When combined with a sharp posterior optic edge, both materials are associated with a low incidence of PCO and giant cell foreign body reaction. Foldable lenses can be inserted with either forceps or with injection devices.²⁶⁹ The latter facilitate consistently reproducible insertion through small incisions while preventing any contact of the lens with debris or microorganisms residing on the patient's external ocular surface.²²⁸

At present, all FDA-approved anterior chamber lenses are single-piece flexible open-loop high molecular weight PMMA and contain an ultraviolet-blocking chromophore. Effective use of an anterior chamber lens depends on appropriate sizing. Anterior chamber IOLs that are too long may induce pupil distortion and physical discomfort, while anterior chamber IOLs that are too short may move or rotate and induce corneal endothelial damage. Anterior chamber IOLs are used most often when there is inadequate capsule support for a posterior chamber IOL. Generally, use of an anterior chamber lens requires a peripheral iridectomy.

The surgeon should have access to a variety of lens styles to select an appropriate IOL for an individual patient.^[A:III] Variations in the preoperative state of the eye, the surgical technique, patient expectation, and surgeon experience and preference affect the decision.

Optical and Refractive Considerations of Cataract Surgery

Standard IOLs, in which the marginal light rays are focused more anteriorly than paraxial light rays, have positive spherical aberration. For the patient, this results in reduced contrast sensitivity.

Aspheric optic IOLs offer the opportunity to improve functional vision and quality of vision by improving contrast sensitivity, decreasing haloes, and improving optical quality. Clinical data have demonstrated a reduction in ocular spherical aberration, improved contrast sensitivity, and improved night driving performance with these lenses.^{270,271} A potential pitfall of some aspheric designs is the induction of aberrations, especially coma, if the IOL should become decentered or tilted off-axis.^{272,273}

Toric IOLs reduce spectacle dependence due to astigmatism. Between 15% and 29% of cataract patients have astigmatism measuring more than 1.50 diopters (D) of corneal or refractive astigmatism.^{274,275} Toric IOLs have been shown to decrease spectacle dependence compared with non-toric monofocal IOLs.²⁷⁶ In addition, they may offer an advantage over incisional astigmatic keratotomy.^{277,278} For a toric IOL to be effective, it must be placed accurately and remain in a stable position.

Monovision and presbyopia-correcting IOL implants are strategies used in an attempt to improve quality of life by reducing spectacle dependence after cataract surgery.²⁷⁹ For each of these strategies, patient selection is critical because certain patient-related factors may be associated with suboptimal postoperative performance and reduced patient satisfaction. Surgeons must understand the individual patient's lifestyle and expectations so the best IOL option can be selected. Patients should be informed of the potential compromise in quality of vision associated with these strategies.^{280,281 [A:III]}

Monovision is a condition in which one eye is corrected for distance vision and the fellow eye is corrected for intermediate or near vision. The mechanism involves the concept of interocular blur suppression where the blurred image from one eye does not interfere with the image from the in-focus eye. A review of 19 contact lens monovision studies in which the dominant eye was corrected for distance demonstrated patient satisfaction in 75% of cases.²⁸² Similarly, when the dominant eye was corrected for distance visual acuity, the overall monovision acceptance rate following cataract and IOL surgery was 90%, in a cataract population that desired independence of spectacle correction.²⁸³ Patients with a history of monovision success are particularly suited for this modality.

Presbyopia-correcting IOLs can be classified as multifocal or dynamic (the lens changes position or shape within the eye).

Multifocal IOLs achieve their effect by dividing incoming light into two or more focal points and can be classified as refractive or diffractive. A Cochrane systematic review concluded that multifocal IOLs were effective at improving near vision when compared with monofocal IOLs and that unaided distance visual acuity was similar in the two groups.²⁸⁴ Adverse effects of multifocal IOLs include reduced contrast sensitivity, haloes around point sources of light, and glare. Whether the improvement in near unaided acuity outweighs the adverse effects of multifocal IOLs will vary among patients, with motivation to achieve spectacle independence likely to be the definitive factor.

In an attempt to mimic human accommodation, dynamic presbyopia-correcting IOLs are designed to change position in the eye with accommodative effort. Available dynamic IOLs have demonstrated limited accommodative ability with no loss of contrast sensitivity.²⁸⁵

Outcomes

The ASCRS National Cataract Database reported that at 3 months postoperatively 85.5% of all patients had a 20/40 or better best-corrected visual acuity (BCVA), 57.2% of patients had 20/25 or better postoperative BCVA, and 74.6% of patients were within ± 1.0 D of target spherical equivalent. Based on 5,788 responses, the mean visual function index score at 3 months postoperatively was 70.3% compared with 55.0% preoperatively. (The score is based on a scale of 0 to 100, with 0 indicating an inability to perform any of the activities.) The European Cataract Outcome Study for 1999 reported that 89% of patients achieved a postoperative visual acuity of 0.5 or more (20/40 or better), the average induced astigmatism was 0.59 D, and 86% of patients

had an induced astigmatism within ± 1.0 D (Results of the European Cataract Outcomes Study, 2000. Unpublished data). This study was conducted in 14 countries with up to 40 participating surgeons during the years 1995 to 1999, and it collected operative and follow-up information on a total of 8,646 patients, including 3,033 patients in 1999.

The American Academy of Ophthalmology National Eyecare Outcomes Network (NEON) database (n=7,626) also found similar rates of success, with an improvement in visual acuity in 92.2% of patients and improvement in VF-14 in over 90% of patients.²⁸⁶ Best-corrected visual acuity of 20/40 was achieved by 89% of all NEON patients and 96% of NEON patients without preoperative ocular comorbid conditions.²⁸⁶ Seventy-eight percent of patients were within ± 1.0 D of target spherical equivalent. Ninety-five percent of patients reported being satisfied with the results of their surgery. Patients who were dissatisfied with the results of their surgery were slightly older and more likely to have ocular comorbidity.

In studies of phacoemulsification cataract surgery performed by ophthalmology residents, the reported range of patients with postoperative BCVA of 20/40 or better was 80% to 91%.²⁸⁷⁻²⁹² If eyes with ocular comorbidities are excluded, the reported range of patients with postoperative BCVA of 20/40 or better was 86% to 98%.²⁹⁰⁻²⁹³

The Cataract Patient Outcomes Research Team (PORT) study identified preoperative characteristics that were independent predictors of improvement after surgery: age, comorbidity, cataract symptom score, and preoperative VF-14 (measure of visual function) score.¹²⁹ These investigators found that patients younger than 65 showed greater improvement than those over 65 and that patients with more severe symptoms and more severe dysfunction showed greater improvement than those with less severe symptoms or dysfunction.¹²⁹ Preoperative Snellen visual acuity was found to be unrelated to the likelihood of improvement in symptoms or self-reported visual function after cataract surgery.^{129,294} In another study, a prospectively validated model found that predictors of improvement included younger age, a poorer preoperative visual function as measured by the ADVS, and absence of diabetes.²⁹⁴ Even patients with diabetes and age-related macular degeneration, however, showed significant improvements after cataract surgery, albeit at a lower magnitude than patients without these conditions.^{295,296} These studies have shown that benefits are greater in those younger than 75 and that the improvement in quality of life for those 75 years old and older is still functionally and statistically significant.

Complications of Cataract Surgery

No broad-based, peer-reviewed, large-scale investigations on complications of cataract surgery have been reported in recent years. A recent small prospective United Kingdom investigation compared outcomes and complication rates of ECCE with small-incision surgery by phacoemulsification. Outcomes regarding uncorrected visual acuity, surgically induced astigmatism, PCO, and surgical complications favored phacoemulsification significantly.²⁵⁰

Complications that may result in a permanent loss of vision are rare. Major complications that are potentially sight-threatening include infectious endophthalmitis, intraoperative suprachoroidal hemorrhage, cystoid macular edema (CME), retinal detachment, corneal edema, and IOL dislocation. A synthesis of the literature published prior to 1992 found weighted mean complication rates of 0.13% for endophthalmitis, 0.3% for bullous keratopathy, 1.4% clinically detectable CME, 3.5% for angiographically demonstrated CME, 0.7% for retinal detachment, and 1.1% for IOL dislocation (see Table 3).²⁹⁷

A national survey of over 100 hospitals in the United Kingdom from 1997 to 1998 found the following results on 18,454 patients age 50 or older.¹⁰⁴ Seventy-seven percent of these patients had surgery performed by phacoemulsification. Rates for events that occurred during surgery were 4.4% for posterior capsule rupture and vitreous loss, 1.0% for incomplete cortical cleanup, 1.0% for anterior chamber hemorrhage and or collapse, and 0.77% for iris damage. Short-term (within 48 hours) perioperative complications included corneal edema (9.5%), increased IOP (7.9%), uveitis (5.6%), wound leak (1.2%), hyphema (1.1%), and retained lens material (1.1%).

TABLE 3 PROPORTION OF EYES EXPERIENCING COMPLICATIONS FOLLOWING CATARACT SURGERY AND INTRAOCULAR LENS IMPLANTATION

Complication	No. of Studies	Range of Complications Results (% of Eyes)	Total No. of Eyes	Pooled Results (% of Eyes)*	Pooled Results Phacoemulsification (% of Eyes)
Major, early					
Endophthalmitis	16	0 - 1.9	30,656	0.13 (0.06-0.17)	0.74†
Major, late					
Angiographic CME	9	0.7 - 11.3	4,236	3.5 (2.9-4.0)	2.62
Clinical CME	43	0 - 7.6	20,671	1.4 (1.2-1.6)†	2.3
Retinal detachment	42	0 - 2.0	33,603	0.7 (0.6-0.8)	0.93
Bullous keratopathy	27	0 - 6.0	15,971	0.3 (0.2-0.4)	0.3
Other, early					
Hypopyon	10	0 - 2.0	3,864	0.2 (0.1-0.2)	2.0‡
Zonular/posterior capsule rupture	38	0 - 9.9	19,052	3.1 (2.9-3.4)	1.8
Iris trauma	8	0 - 9.1	5,147	1.3 (1.0-1.6)	0.7
Anterior chamber hemorrhage	19	0 - 4.0	7,765	0.5 (0.4-0.7)	0.4
Vitreous loss	26	0 - 4.0	14,622	0.8 (0.6-1.0)†	0.24
Wound gape/ iris prolapse	17	0 - 3.0	7,499	0.6 (0.4-0.8)	0.2
Choroidal hemorrhage	3	0 - 2.0	3,638	0.3 (0.1-0.5)	§
Vitreous hemorrhage	5	0 - 8.0	4,386	0.3 (0.2-0.5)	§
Other, late					
Uveitis	30	0 - 13.3	11,339	1.8 (1.5-2.1)†	3.1
Increased IOP (open angle)	34	0 - 19.7	11,376	1.2 (1.0-1.4)	1.0
Increased IOP (closed angle)	11	0 - 1.6	4,391	0.2 (0.1-0.3)	1.0

MODIFIED FROM: Powe NR, Schein OD, Gieser SC et al. Synthesis of the literature on visual acuity and complications following cataract extraction with intraocular lens implantation. Arch Ophthalmol 1994;112:239-52.

NOTE: This table is based on a synthesis of the literature and does not account for variation in follow-up intervals.

CI = confidence interval; CME = cystoid macular edema; IOP = intraocular pressure

* Pooled result and 95% CI weighted by sample size of studies.

† Pooled result and 95% CI weighted by quality score and sample size.

‡ Only one study that reported data only for phacoemulsification.

§ No studies found that reported data only for phacoemulsification.

The European Cataract Outcome Study reported an average rate of intraoperative complications of 3.1% in 1999, with a rate of 1.8% for posterior capsule rupture and 1.3% for vitreous loss (Results of the European Cataract Outcomes Study, 2000. Unpublished data).

A retrospective study from New Zealand of 1,793 consecutive patients who underwent phacoemulsification reported a rate of 1.8% for posterior capsule rupture and a rate of 1.2% for rhegmatogenous retinal detachment.²⁹⁸ A population-based study found that the risk of retinal detachment after cataract extraction increased over the study period, with a cumulative probability of retinal detachment of 1.79% 20 years after surgery.²⁹⁹ There was no statistically significant difference in the probability of retinal detachment after ECCE compared with phacoemulsification.

There is a recognized tendency for transient elevation of IOP in the early postoperative period. Although this rarely causes serious sight-threatening complications, high IOP can induce postoperative pain, and some eyes may be susceptible to optic nerve damage or vascular occlusion. The likelihood for IOP elevation increases if excess amounts of the OVD remain in the eye at the close of surgery.³⁰⁰ Prophylaxis against spikes of IOP consists primarily of adequate removal of the OVD. The evidence for the benefit of pharmacologic prophylaxis is inconsistent at best; however, it appears that topical aqueous suppressants and intracameral carbachol are most beneficial.³⁰¹⁻³¹⁹ Surgeons should attempt a complete OVD removal and pay particular attention to any material trapped behind the IOL.^[A:III]

Clinically significant CME occurs infrequently after routine uncomplicated small-incision cataract surgery and often responds well to medical therapy; however, recalcitrant cases may be associated with permanent loss of central visual acuity. Risk factors that increase the tendency for CME include presurgical uveitis, intraoperative capsule rupture with vitreous loss, retained lens fragments, diabetic retinopathy, macular pucker, prior vitreoretinal surgery, nanophthalmos, retinitis pigmentosa, and CME in the fellow eye after surgery. Cystoid macular edema is generally associated with post-surgical ocular inflammation; as a result topical anti-inflammatory agents are used in an attempt to reduce the inflammatory response to cataract surgery and to treat established CME. There is evidence that nonsteroidal anti-inflammatory drugs (NSAIDs) alone or in combination with corticosteroids are more effective than topical corticosteroids alone in preventing and treating CME.³²⁰⁻³³⁰ At present, there is no firmly established specific protocol for preventing CME. Additional information on adverse perioperative outcomes is summarized in Table 4.

TABLE 4 PERIOPERATIVE ADVERSE EVENTS

	NEON ²⁸⁶ (n=2603 with 5 data forms)	Cataract PORT ²⁹⁷ (n=717)
Intraoperative (%)		
Posterior capsular or zonular rupture	1.6	1.95
Vitreous loss/anterior vitrectomy or aspiration	1.1	1.39
Iris/ciliary body injury	0	0.84
Loss of nuclear material into vitreous	<1	0.28
Suprachoroidal hemorrhage	0	0.14
Retrolbulbar hemorrhage	0	0
Postoperative (%)^{* †}		
CME	NR [‡]	3.21
Iris abnormalities	NR [‡]	2.51
Corneal edema	<1	1.95
Wound leak or rupture	<1	0.84
IOL dislocation, removal, or exchange	<1	0.28
Endophthalmitis	<1	0.14
Retinal tear, break, or detachment	<1	0.14
Visually significant CME	<1	NR [‡]
Persistent iritis	1.1	NR

CME = cystoid macular edema; IOL = intraocular lens; NEON = National Eyecare Outcomes Network; NR = not reported; PORT = Patient Outcomes Research Team

* Occurring by time of final refraction visit for NEON patients.

† Occurring within 4 months following surgery for Cataract PORT patients.

‡ Either Cataract PORT or NEON did not collect data on this item.

Complications of Intraocular Lenses

Complications specific to the IOL occur infrequently. The most common reasons for IOL explantation include incorrect power, opacification, decentration or dislocation, and glare or optical aberrations.³³¹ Intraocular lenses may be damaged during implantation, and it may be necessary for the surgeon to consider intraoperative implant exchange.

The accuracy of IOL power selection is impaired when the preoperative ocular measurements are unreliable such as following prior keratorefractive surgery (see Cataract Surgery Following Refractive Surgery section). When an unacceptable refractive error results following IOL implantation, the surgeon and patient should discuss further surgical intervention, and the risks of intervention must be weighed against the alternatives of spectacle or contact lens correction.^[A:III] Surgical alternatives to IOL exchange include keratorefractive surgery and secondary ciliary sulcus implantation of a piggyback IOL.

Opacification of the IOL optic is rare and has been reported more often with hydrophilic acrylic materials.³³²⁻³³⁶ The complication of interseudophakic opacification can occur when lens epithelial cells migrate in between two piggybacked IOLs that have both been implanted within the capsular bag.^{183,184} This fibrocellular material is difficult to remove and may require explantation of both IOLs.

A malpositioned posterior chamber IOL can cause visual complaints, such as edge glare or intraocular inflammation associated with iris chafing,³³⁷ pigment dispersion, and pupillary capture of the optic. This complication is least likely with capsular bag implantation of the IOL. Posterior chamber IOL decentration can result from a damaged haptic, asymmetric capsular contraction and fibrosis, a torn posterior capsule or zonular dialysis, an insufficiently long IOL implanted in the ciliary sulcus, and placement of one haptic in the ciliary sulcus and the other inside the capsular bag.

Delayed posterior dislocation of the IOL may result from insufficient capsular or zonular support. Plate haptic silicone IOLs can dislocate posteriorly following neodymium: yttrium-aluminum-garnet laser (Nd:YAG) capsulotomy and, rarely, spontaneously from capsular contraction. Posterior dislocation of the entire IOL and capsular bag complex can be caused by trauma or can occur spontaneously in eyes with weak zonules, such as those with pseudoexfoliation.^{338,339}

Certain design characteristics of the posterior chamber IOL optic such as a square peripheral edge, a flat anterior surface, and multifocality are more likely to result in problematic images.³⁴⁰⁻³⁴³ These symptoms generally become more tolerable with time and reassurance but may rarely be so bothersome as to require surgical explantation of the IOL.

Intraocular lenses may cause unwanted symptomatic optical images such as with IOL opacification, cracked or damaged optics, and lens decentration.

Malpositioned anterior chamber IOLs may result from improper sizing, from iris tuck following implantation, or from rotation of a haptic through a peripheral iridectomy. Excessive anterior chamber IOL mobility can lead to corneal endothelial decompensation.

A rare late complication of IOL implantation is uveitis-glaucoma-hyphema syndrome.

Ocular Comorbidities

Preoperative ocular comorbidities often have a significant effect on the outcome of cataract surgery.^{102,294,344} Most comorbid conditions are associated with the potential for reduced improvement in visual function or BCVA,³⁴⁵ and the patient should be adequately informed and counseled during the care process.^[A:III] Comorbid conditions found in patients with cataracts and the special considerations associated with these conditions are listed in Table 5.

TABLE 5 SELECTED OCULAR COMORBIDITIES

Comorbidity	Special Considerations
Amblyopia	Reduced visual potential
AMD ³⁴⁶⁻³⁴⁸	Unrecognized preoperative choroidal neovascularization
Diabetic retinopathy ³⁴⁹⁻³⁵⁴	Progression of retinopathy
	CSME
	Poorly dilating postoperative pupil
	Neovascularization of the iris, neovascularization of the angle, and neovascular glaucoma
Fuchs' corneal endothelial dystrophy ^{355,356}	Reduced visualization during surgery
	Prolonged postoperative corneal edema
	Pseudophakic bullous keratopathy
Glaucoma ³⁵⁷⁻³⁶²	Higher IOP during the first postoperative week
	Reduced function of prior filtering surgery
Pseudoexfoliation syndrome ³⁶³⁻³⁶⁶	Intraoperative miosis
	Zonular laxity or instability
	Vitreous loss
	Floppy iris and tendency for iris prolapse into the cataract incision
	Accelerated PCO
	Anterior capsulorrhexis contraction
	IOL tilt and decentration
	Late (decades) dislocation of IOL possible
Retinopathy of prematurity ³⁶⁷	Intraoperative miosis
	Traction retinal detachment
	Loose zonules
Uveitis ³⁶⁸⁻³⁷²	Posterior synechiae
	Protein and cellular deposits on the lens implant
	CME
	Secondary glaucoma
	Prolonged postoperative inflammation

AMD = age-related macular degeneration; CME = cystoid macular edema; CSME = clinically significant macular edema; IOL = intraocular lens; IOP = intraocular pressure; PCO = posterior capsule opacification

In addition to ocular comorbidities, other characteristics of the patient or eye may be associated with a higher risk for intraoperative and postoperative complications. High-risk characteristics include a history of previous eye surgery, special types of cataracts, very large and very small eyes, deeply set eyes, eyes with small pupils or posterior synechiae, eyes with scarred or cloudy corneas, eyes with weak or absent zonules, prior ocular trauma, and the systemic use of alpha-1a antagonists. Each set of circumstances poses unique challenges (see Table 6). As with ocular comorbidities, patients with high-risk characteristics should be informed about the specific impact of their condition on the expected course and outcome of surgery, along with options that may be considered in the event that complications occur.^[A:III]

TABLE 6 HIGH-RISK CHARACTERISTICS FOR INTRAOPERATIVE AND POSTOPERATIVE COMPLICATIONS

High-Risk Characteristic	Special Considerations
Cloudy cornea	Reduced visibility
	Worsening of corneal clarity
Deeply set eye, narrow lid fissure, or prominent brow	Reduced visibility
	Poor access to the superior limbus
	Pooling of irrigation fluid
Dense brunescent nuclear cataract ^{373,374}	Concomitant zonular laxity and intraoperative miosis
	Little cortex to protect the capsule during phacoemulsification
	Increased phacoemulsification time with increased risk of postoperative corneal edema
	Greater risk of thermal and mechanical injury to the cornea and iris with phacoemulsification
	Increased risk of posterior capsule rupture
High hyperopia ³⁷⁵⁻³⁷⁷	Shallow anterior chamber with increased risk of endothelial trauma
	Increased risk of iris trauma and prolapse
	Difficulty calculating lens implant power
	Intraoperative suprachoroidal effusion (particularly in nanophthalmic eyes)
High myopia ³⁷⁸⁻³⁸²	Anterior chamber depth fluctuation
	Difficulty calculating lens implant power especially with posterior staphyloma
	Increased risk of retinal detachment
Miotic pupil ³⁸³⁻³⁸⁸	Poor visualization
	Increased risk for capsule tear/vitreous prolapse
	Increased risk for iris damage and prolapse
Potential need for vitreoretinal surgery	Silicone IOLs may compromise subsequent surgical visibility if posterior segment silicone is needed
Prior glaucoma filtration surgery ³⁸⁹⁻³⁹¹	Increased filtration through the bleb during surgery
	Decreased filtration or bleb failure following surgery
	Postoperative hypotony
	Zonular laxity
Prior keratorefractive surgery ³⁹²⁻³⁹⁴	IOL power calculation inaccuracy
	Transient hyperopic shift immediately after surgery in eyes with a history of radial keratotomy
	Dehiscence of refractive keratotomy incision
	Corneal aberrations with glare and haloes
Prior pars plana vitrectomy ³⁹⁵⁻³⁹⁷	Conjunctival scarring
	Intraoperative anterior chamber depth fluctuation, especially severe deepening
	Intraoperative miosis
	Increased nuclear sclerosis
	Increased frequency of posterior capsule plaques
	Weakened lens capsule and zonules
Prior penetrating keratoplasty ³⁹⁸	Poor visualization
	Graft rejection or failure
	IOL power calculation inaccuracy

TABLE 6 HIGH-RISK CHARACTERISTICS FOR INTRAOPERATIVE AND POSTOPERATIVE COMPLICATIONS (CONTINUED)

High-Risk Characteristic	Special Considerations
Prior scleral buckling surgery ³⁹⁹⁻⁴⁰¹	Change in axial length affects IOL power calculation
	Conjunctival scarring
Posterior polar cataract ⁴⁰²⁻⁴⁰⁴	Defective posterior capsule
Posterior synechiae	Intraoperative miosis
	Prolonged postoperative inflammation
	Inflammatory deposits on IOLs
	Iris bleeding
Relative anterior microphthalmos ⁴⁰⁵	Damage to iris, cornea, and posterior capsule
Shallow anterior chamber	Iris injury
	Iris prolapse
	Postoperative corneal edema
Use of systemic sympathetic alpha-1a antagonist medication for treatment of prostatic hypertrophy ^{406,407}	Intraoperative floppy iris syndrome (IFIS)
White cataract (mature cortical cataract) ⁴⁰⁸⁻⁴¹¹	Difficulty performing the capsulorrhexis (capsule staining may be helpful in completing capsulorrhexis) ⁴¹²
	Lens intumescence
Zonular laxity or dehiscence (e.g., pseudoexfoliation) ⁴¹³⁻⁴¹⁵	Phacodonesis
	Vitreous prolapse around the lens equator
	Loss of the cataract into vitreous
	Postoperative lens implant decentration
	Increased difficulty in capsulorrhexis and cortical clean-up
	Capsular contraction with late IOL/capsular bag decentration or dislocation

IOL = intraocular lens

Systemic Comorbidities

Systemic comorbidities that may be of importance intraoperatively are diabetes mellitus, pulmonary dysfunction, poorly controlled blood pressure, musculoskeletal disorders causing positional difficulties, tremor, severe hearing impairment, anxiety disorders, mental retardation, dementia, and coagulopathies. For patients with complex medical conditions, it may be beneficial to coordinate care with the patient's primary care physician. Depending on the planned anesthesia and sedation, appropriate measures should be taken to stabilize and monitor the condition.^[A:III]

There is no strong evidence favoring continuation or discontinuation of anticoagulants during cataract surgery for anticoagulated patients.^{416,417} In a study of 19,283 eyes, the incidence of adverse medical and ophthalmic events was low and statistically indistinguishable in patients who either continued or discontinued anticoagulant or antiplatelet medication use before cataract surgery.⁴¹⁸ Several uncontrolled case series reported minimal or no complications in patients who were maintained on their anticoagulants prior to cataract surgery.⁴¹⁹⁻⁴²⁷ There is no strong evidence favoring continuation or discontinuation of antiplatelet agents; small case series do not show adverse effects from continuation of these agents when phacoemulsification is performed.^{419,428-430}

The risk of discontinuing anticoagulant or antiplatelet medications depends on the condition for which they were prescribed. Generally, patients can be left on anticoagulant or antiplatelet medications if routine cataract surgery is anticipated. Alternatives to retrobulbar injections should be considered for these patients.^{417 [B:III]}

Recommendations from the American Heart Association for prevention of bacterial endocarditis do not include cataract surgery as a procedure for which systemic antibiotic prophylaxis is necessary.⁴³¹ The American Academy of Orthopaedic Surgeons currently does not have guidelines for antibiotic prophylaxis for patients with joint prostheses who are undergoing cataract surgery.⁴³²

Combined Surgery and Special Circumstances

Cataract Surgery and Glaucoma

When a candidate for cataract surgery also has glaucoma, surgical treatment options include cataract and IOL surgery alone, combined cataract and penetrating or nonpenetrating glaucoma surgery, cataract and IOL surgery combined with endoscopic cyclophotocoagulation, cataract and IOL surgery following filtration surgery, or glaucoma surgery after cataract surgery.

Cataract surgery with IOL implantation alone sometimes results in a modest reduction of IOP.^{357,359,361,433} Generally, a glaucoma procedure combined with cataract surgery is not as effective as glaucoma surgery alone in lowering IOP.^{434,435} Separating the cataract and glaucoma incisions results in lower IOP than a one-site combined procedure, but the differences in outcomes are small.^{434,435} Phacoemulsification combined with trabeculectomy provides good IOP control as well as improved BCVA compared with preoperative vision.⁴³⁶⁻⁴³⁸ Endoscopic cyclophotocoagulation combined with cataract surgery is an alternative procedure for patients who require both cataract and glaucoma surgery, although it may be less effective than trabeculectomy.⁴³⁹ Potential benefits of a combined procedure (cataract extraction with IOL implantation and trabeculectomy) are protection against the IOP rise that may complicate cataract surgery alone, more rapid visual recovery, and long-term glaucoma control with a single operation. Despite these presumed advantages, the evidence does not support combined cataract-glaucoma surgery over two-stage surgery.⁴³⁴ Additionally, combined procedures are technically more complex.

There are disadvantages to performing filtration surgery several months before cataract surgery. These include delayed visual recovery, increased perioperative and anesthetic risks, and the possibility of inducing bleb dysfunction at the time of cataract surgery.

The benefit of the adjunctive use of antifibrotics (mitomycin-C and 5-fluorouracil) to reduce the potential for bleb failure in combined phacotrabeculectomy remains controversial. While it appears that mitomycin-C may be effective in producing lower long-term IOPs when used with combined procedures, 5-fluorouracil is not.^{434,435,440} Potential vision-threatening complications, such as bleb-related endophthalmitis,⁴⁴¹⁻⁴⁴³ hypotony maculopathy,^{444,445} and late-onset bleb leaks⁴⁴⁶ should be considered in the decision to use antifibrotic agents.^[A:III]

The decision about the various surgical treatment options will be based on a number of factors, including the patient's response to medical or laser surgical treatment of the glaucoma, the degree of optic nerve damage, changes in the visual field, severity of the cataract, and the surgeon's experience.

Cataract Surgery and Penetrating Keratoplasty

The presence of endothelial dystrophy presents a challenge to the cataract surgeon in predicting how well the compromised cornea will function following cataract surgery. Evaluation of the corneal endothelium is helpful in assessing the cataract patient preoperatively. A slit-lamp biomicroscopic examination that demonstrates microcystic edema, or stromal thickening, and/or central corneal pachymetry greater than 640 microns,⁴⁴⁷ and/or low central endothelial cell counts by specular microscopy indicate an increased likelihood of corneal failure following cataract surgery. An important piece of history that indicates endothelial pump function is whether the patient experiences "foggy vision" upon awakening in the morning. If the lack of evaporation while asleep leads to symptomatic corneal edema, then the likelihood of decompensation after cataract surgery is high. Under these circumstances, a combined procedure of cataract extraction, IOL implantation, and penetrating keratoplasty may be considered. With borderline endothelial reserve, a more peripheral incision, either temporal clear cornea or corneoscleral, may preserve more endothelial cells.⁴⁴⁸

There are several reasons to consider cataract surgery at the time of penetrating keratoplasty, even in the presence of a mild cataract. These benefits include the following:

- ◆ Cataracts may progress more rapidly after penetrating keratoplasty.
- ◆ The use of topical corticosteroids following surgery may hasten PSC cataract development.
- ◆ Cataract surgery subsequent to penetrating keratoplasty may damage the corneal graft.
- ◆ Surgery is limited to a single procedure.
- ◆ Visual rehabilitation is more rapid.

The use of capsule staining dyes may improve the likelihood of achieving an intact capsulorrhexis when performing a combined penetrating keratoplasty and cataract extraction.⁴⁴⁹

Because the postkeratoplasty corneal curvature is not known at the time of a combined procedure, IOL calculations are less accurate. Therefore, some surgeons prefer to perform penetrating keratoplasty first followed by cataract removal later after the corneal graft has stabilized. If the cataract is removed following stabilization of corneal graft keratometry, a more predictable IOL power and hence refractive result may be possible.⁴⁵⁰⁻⁴⁵² In some cases this approach has the advantage of reducing the amount of time the eye is open during the penetrating keratoplasty surgery.

An alternative to penetrating keratoplasty for the treatment of endothelial decompensation is deep lamellar endothelial transplantation of the endothelium and posterior stroma.^{453,454} This procedure can be combined with phacoemulsification and foldable IOL implantation. Among other potential advantages, this approach preserves the anterior corneal curvature and therefore should improve IOL power predictability compared with combined penetrating keratoplasty and cataract surgery.

If the indication for considering corneal transplantation is the presence of a central opacity rather than endothelial dysfunction and adequate clear cornea is present in the midperiphery, then the surgeon has the option of performing cataract surgery followed by a sphincterotomy, establishing a clear visual axis.⁴⁵⁵ The use of a capsule staining dye can facilitate the ability to perform cataract surgery safely in the presence of a mild corneal opacity, possibly avoiding the need for corneal transplantation when the principal indication is the need for a clearer cornea to perform cataract surgery safely.⁴⁵⁶

Cataract Surgery and Vitreoretinal Surgery

Cataract surgery may be combined with vitreoretinal surgery. Removal of an opaque lens may be necessary to improve the view of the retina during vitreoretinal surgery. However, combined vitreoretinal surgery and lens extraction might be considered because cataracts can progress postoperatively as a result of vitreoretinal surgery.

Combined vitreoretinal surgery and phacoemulsification with IOL implantation has been successfully employed.^{457,458} Advantages of combined surgery are the single operative procedure and anesthesia as well as reduced postoperative recovery time.

Possible disadvantages of simultaneous cataract and vitreoretinal surgery include prolonged surgical time, cataract wound dehiscence caused by globe manipulation during subsequent vitreoretinal surgery, intraoperative miosis after cataract extraction, IOL decentration or optic capture, and undesirable optical effects during vitreoretinal surgery if the IOL is implanted before the posterior segment procedure. Silicone IOLs are best avoided in these cases because condensation of gas or silicone oil on the posterior surface of the lens can interfere with the intraoperative view of the posterior segment.^{459,460}

Cataract Surgery Following Refractive Surgery

Patients who have had prior refractive surgery present specific challenges for cataract surgery with respect to both physical changes related to the previous refractive procedure and to the accurate calculation of IOL power as a result of the alteration of corneal curvature. Surgical strategies vary with the nature of the prior refractive surgery.

Following incisional refractive surgery, radial and astigmatic keratotomy, it is best to avoid having the new cataract incision cross or intersect the pre-existing incisions, as this could lead to wound leak, delayed healing, and potentially irregular astigmatism.^{461-464 [A:III]} Microincision methods may be helpful in this situation. In cases of extensive prior radial keratotomy, the surgeon should

consider lowering fluid inflow to reduce turbulence and prevent high IOP because the prior incisions may gape and induce transient hyperopia and changes in astigmatism.^[B:III] This may prolong corneal shape recovery after surgery.⁴⁶¹

Generally, eyes that have undergone prior laser refractive surgery do not cause anatomic challenges during cataract surgery. On the other hand, in cases with previously implanted phakic refractive IOLs, the refractive IOL must be removed prior to or concomitant with cataract surgery.

Accurate IOL power calculation after refractive surgery is challenging yet critical, because this particular group of patients has demonstrated a desire for spectacle independence. Each type of refractive surgery presents a unique problem for determining the correct IOL power. In the case of radial keratotomy, the induced central corneal flattening renders the traditional keratometric readings inaccurate, because the paracentral area, read by keratometers, may not reflect the true central power of the cornea.^{465,466} Other methods, such as contact lens overrefraction, the clinical history method (which requires knowledge of presurgical keratometry and refraction) or using automated computerized videokeratography (topography) can help in determining true central corneal power.^{465,467,468}

After excimer laser refractive surgery (by either surface or intrastromal photoablation), corneal power readings with traditional keratometers, automated refractors, and topographers are often incorrect as result of the surgical alteration of the anterior corneal curvature and the changed relationship between anterior and posterior corneal powers. As a result, there is a tendency for hyperopic refractive errors after cataract surgery in eyes with prior myopic photoablation.^{392,469-472} Similarly, eyes having prior hyperopic photoablation are prone to myopic optical errors after cataract surgery. A number of formulas, some of which require knowledge of prior corneal power, refraction, and diopters of laser vision correction, have been developed to help determine IOL power following refractive surgery, but there is presently no consensus about a best method.⁴⁷³⁻⁴⁷⁸ It may be beneficial to utilize the Aramberri Double-K method to refine IOL power determination, because the surgically altered corneal curvature may render some calculation formulas less accurate.⁴⁷⁹ Patients should be informed of the potential inaccuracies of IOL power calculation and that further surgery may be necessary to achieve spectacle independence.^[A:III]

Cataract in the Functionally Monocular Patient

A functionally monocular patient is one who is primarily dependent on the eye being considered for cataract surgery. There may be significant ocular comorbidity or other high-risk characteristics in such eyes.^{480,481} The indications for surgery in the functionally monocular patient are the same as for other patients; that is, when the cataract-impaired vision no longer meets the patient's needs and the anticipated benefits of surgery exceed the risks. Delaying surgery until the cataract is very advanced may increase surgical risk and slow visual recovery. Cataract surgery for these patients results in a greater improvement in functional vision than surgery in binocularly sighted patients.⁴⁸² When cataract surgery is contemplated in a functionally monocular patient, the ophthalmologist has an obligation to inform the patient that blindness is one of the risks of cataract surgery and also that blindness can result from worsening ocular comorbidity following surgery.^{483 [A:III]}

Second-Eye Surgery

Clinical studies have provided convincing evidence that binocular summation occurs in individuals who have similar visual acuities in the two eyes and occurs at low illuminance levels.⁴⁸⁴⁻⁴⁸⁹ In addition, these studies have demonstrated that binocular gain or summation is less likely when the visual acuities in the two eyes are dissimilar or when the individual is older. Indeed, these individuals with dissimilar acuities in the two eyes may exhibit binocular inhibition. Patients with a cataract and dissimilar vision in the two eyes (or one eye with cataract extraction and the second eye with a cataract) have demonstrated binocular inhibition.⁴⁸⁸ A large epidemiological study demonstrated that persons who exhibited binocular inhibition were more likely to have driving difficulties compared with those who did not have binocular inhibition.⁴⁸⁴ These data taken together suggest an improvement in binocular visual function and quality of life if cataract surgery in the second eye provides similar visual acuities in the two eyes.

Studies comparing the outcomes of first- and second-eye cataract surgeries concluded that patients who had surgery in both eyes had greater improvement in functional status than those who underwent surgery in only one eye.⁴⁹⁰⁻⁴⁹⁵ Patients who had surgery in both eyes were significantly more satisfied with their visual function than patients who had surgery in only one eye.^{491,496} Another study demonstrated that the cataractous eye interfered with the visual function of the pseudophakic eye and that, after second-eye surgery, complaints of visual disability were eliminated.⁴⁹⁷ One study found that stereoacuity increased from 32% of patients after first-eye surgery to 90% after second-eye surgery. Also, binocular horizontal field of vision improved in 36% of patients. The number of patients able to meet the driving standard increased from 52% after first-eye surgery to 86% after second-eye surgery.⁴⁹⁸ Cataract surgery for both eyes is an appropriate treatment for patients with bilateral cataract-induced visual impairment.^{491,493-495,499}[A:II]

The indications for second-eye surgery are the same as for the first eye. The outcome of surgery on the first eye may affect the timing of second eye surgery. In some patients, a byproduct of reducing ametropia in the first operated eye may be anisometropia. This may result in impaired stereoacuity and a reduction in a patient's ability to perform daily activities. In patients whose anisometropia interferes with visual function, second-eye surgery may be appropriate at an earlier stage of cataract development.^{493,494,500}

Determining the appropriate interval between the first-eye surgery and the second-eye surgery is influenced by several factors: the patient's visual needs and preferences, visual acuity and function of the second eye, the medical and refractive stability of the first eye, and the degree of anisometropia. Prior to performing second-eye surgery, the refractive error of the first eye should be determined to assist in selecting the appropriate IOL power for the second eye.^[A:III] Sufficient time should elapse to diagnose and treat any early postoperative complication such as endophthalmitis, which has a peak occurrence of between 4 to 6 days,⁵⁰¹⁻⁵⁰³ and for the patient and the ophthalmologist to be satisfied with the recovery and outcome of the first-eye surgery.^[A:III]

Simultaneous Bilateral Cataract Surgery

Most ophthalmologists do not perform bilateral simultaneous cataract surgery. The rapid visual recovery associated with small-incision cataract surgery under topical anesthesia has led to increased interest in this approach in some international centers,⁵⁰⁴⁻⁵¹¹ particularly in health care delivery systems with long waiting times for cataract surgery.⁵⁰⁴ Assuming that it is the preference of a patient anticipating cataract surgery in both eyes, bilateral simultaneous surgery has advantages and disadvantages that must be carefully weighed. Foremost is the risk of potentially bilateral blinding complications, such as infectious endophthalmitis. In published reviews of simultaneous bilateral cataract extraction, however, no complications that resulted in bilateral visual loss were reported.⁵⁰⁴⁻⁵¹⁰ Another disadvantage of this approach is the inability to adjust surgical plans for the second eye on the basis of results from first eye surgery.^[A:III]

In addition to an unanticipated refractive outcome in the first eye, IOL selection for the second eye may also be altered because the patient decides on a different target refraction based on his or her experience with the first eye.

Indications reported for simultaneous bilateral cataract surgery include the need for general anesthesia in the presence of bilateral visually significant cataracts; rare occasions where travel for surgery and follow-up care is a significant hardship for the patient; and when the health of the patient may limit surgery to one operation.^{505,508} If bilateral simultaneous surgery is considered as an option, the patient should be carefully informed of the potential disadvantages.^[A:III]

Discharge from Surgical Facility

Typical criteria for discharge after ambulatory surgery are as follows:

- ◆ Vital signs are stable.
- ◆ Preoperative mental state is restored.
- ◆ Nausea and vomiting are controlled.
- ◆ Pain is absent or minimal.
- ◆ An escort is available if necessary.

- ◆ Postsurgical care has been reviewed with the patient or escort and written postoperative instructions have been provided.
- ◆ Follow-up appointment has been scheduled.

Operative complications of an ocular or medical nature are possible indications for unplanned postoperative hospitalization. In the Study of Medical Testing for Cataract Surgery (n=19,250 surgeries), there were 61 (0.3%) hospitalizations on the day of cataract surgery.¹⁶³ Ocular complications that may require hospitalization include hyphema, uncontrolled elevated IOP, threatened or actual expulsive suprachoroidal hemorrhage, retrobulbar hemorrhage, severe pain, or other ocular problems requiring acute management or careful observation. Medical complications can include cardiac or respiratory instability, a cerebrovascular episode, diabetes mellitus requiring acute management, uncontrolled nausea or vomiting, acute urinary retention, acute psychiatric disorientation, or other medical conditions requiring management in an acute care setting with careful monitoring.

Situations under which extended observation might be warranted include the following:

- ◆ Medical conditions are present that require prolonged postoperative observation by nurses or other skilled personnel.
- ◆ Patient is mentally debilitated or diagnosed as mentally ill.
- ◆ Patient cannot exercise self-care (or responsible care is unavailable) during the immediate postoperative period.
- ◆ Patient is functionally monocular and has had cataract surgery in the eye on which they are primarily dependent.

Postoperative Management

The ophthalmologist who performs the cataract surgery has a unique perspective and thorough understanding of the patient's intraoperative course, postoperative condition, and response to surgery. The operating ophthalmologist is responsible for the care of the patient during the postoperative interval, the time in which most complications occur and within which stable visual function is achieved, and has an ethical obligation to the patient that continues until postoperative rehabilitation is complete. The operating ophthalmologist should also provide those aspects of postoperative eye care that are within the unique competence of the ophthalmologist (which do not include those aspects of postoperative care permitted by law to be performed by auxiliaries, and, for non-ophthalmological physicians, may also exclude additional functions). If such follow-up care is not possible, the operating ophthalmologist must make arrangements before surgery to refer the patient to a properly licensed, qualified health care professional for postoperative care with the prior approval of the patient and the health care professional.^{161,512 [A:III]} In rare special circumstances, such as emergencies or if no ophthalmologist is available, the operating ophthalmologist may make different arrangements for the provision of those aspects of postoperative eye care within the unique competence of the ophthalmologist, as long as the patient's rights and welfare are the primary considerations.

The ophthalmologist who performs surgery has an obligation to inform patients about appropriate signs and symptoms of possible complications, eye protection, activities, medications, required visits, and details for access to emergency care.^[A:III] The ophthalmologist should also inform patients of their responsibility to follow advice and instructions provided during the postoperative phase and to notify the ophthalmologist promptly if problems occur.^[A:III] Patients should always have access to an ophthalmologist for appropriate care if serious problems arise.^[A:III]

Most ophthalmologists provide all postoperative care in their offices. Other members of a team of eye care professionals may also participate in the comanagement of postoperative care. The operating ophthalmologist is responsible to the patient for those aspects of postoperative care delegated to other eye care professionals.^{161 [A:III]}

Postoperative regimens of topically applied antibiotics, corticosteroids, and NSAIDs vary among practitioners. There are no controlled investigations that establish optimal regimens for the use of topical agents; therefore, it is the decision of the operating surgeon to use any or all of these products singly or in combination. Complications of postoperative medications include elevated IOP with corticosteroids and allergic reactions to antibiotics. Rarely, significant corneal reactions,

including epithelial defects and stromal ulceration and melting, have been reported with topical ocular NSAIDs.⁵¹³⁻⁵¹⁵

Postoperative Follow-up

The frequency of postoperative examinations is based on the goal of optimizing the outcome of surgery and swiftly recognizing and managing complications. This requires prompt and accurate diagnosis and treatment of complications of surgery, providing satisfactory optical correction, educating and supporting the patient, and reviewing postoperative instructions. Table 7 provides guidelines for follow-up based on consensus in the absence of evidence for optimal follow-up schedules. Prospective studies from the United Kingdom have reported that omitting an examination on the day after uncomplicated cataract surgery for the routine patient was associated with a low frequency of serious ocular complications.^{516,517}

Patient Characteristics	First Visit	Subsequent Visits
Without high risks or signs or symptoms of possible complications following small-incision cataract surgery	Within 48 hours of surgery	Frequency and timing dependent upon refraction, visual function, and medical condition of the eye
High risk; functionally monocular; glaucoma or glaucoma suspect patients; intraoperative complications	Within 24 hours of surgery	More frequent follow-up usually necessary

Patients should be instructed to contact the ophthalmologist promptly if they experience symptoms such as a significant reduction in vision, increasing pain, progressive redness, or periocular swelling, because these symptoms may indicate the onset of endophthalmitis.^[A:III]

In the absence of complications, the frequency and timing of subsequent postoperative visits depend largely on the size or configuration of the incision; the need to cut or remove sutures; and when refraction, visual function, and the medical condition of the eye are stabilized. More frequent postoperative visits are generally indicated if unusual findings, symptoms, or complications occur, and the patient should have ready access to the ophthalmologist's office to ask questions or seek care.^[A:III]

Components of each postoperative examination should include:^[A:III]

- ◆ Interval history, including use of postoperative medications, new symptoms, and self-assessment of vision.
- ◆ Measurement of visual function (e.g., visual acuity, pinhole testing).
- ◆ Measurement of IOP.
- ◆ Slit-lamp biomicroscopy.
- ◆ Counseling/education for the patient or patient's caretaker.
- ◆ Management plan.

A dilated ophthalmoscopic or slit-lamp microscopic examination is indicated if there are new visual symptoms or signs. In the absence of symptoms, no study has demonstrated that a dilated fundus examination results in earlier detection of retinal detachment.

A final refractive visit should be made to provide an accurate prescription for spectacles to allow for the patient's optimal visual function.^[A:III] The timing and frequency of refraction will depend on patient needs, the amount of astigmatism, and the stability of the measurement. Sutures, if used, may be cut or removed by the ophthalmologist to reduce astigmatism. Optical correction can usually be prescribed between 1 and 4 weeks after small-incision surgery⁵¹⁸ and between 6 and 12 weeks after sutured large-incision cataract extraction surgery.

Posterior Capsular Opacification

The most common problem following cataract surgery is PCO, which has had a reported incidence of up to 50% by 2 years postoperatively.⁵¹⁹ The reported rate of PCO varies considerably with suggestions that the incidence has now decreased.⁵²⁰

The relationship between lens style and PCO has generated interest in preventing PCO by changing IOL material⁵²¹⁻⁵²³ and design. Design factors that have been implicated in reducing PCO include the convexity⁵²⁴ and, in particular, the edge profile of the IOL optic.⁵²⁵⁻⁵⁵³ Truncated-edge design has been associated with reduced PCO for both silicone and acrylic IOLs in a number of well-controlled studies. Posterior capsular opacification rates are generally found to be higher for PMMA and hydrophilic IOL optics, but no consistent difference is found between silicone and hydrophobic acrylic IOLs when a sharp edge is present on the IOL optic. Some evidence indicates a lower PCO rate when the anterior capsulorrhexis overlies the entire optic,^{532,554} but at least one clinical study failed to find a significant difference whether the capsulorrhexis edge was completely over, completely off, or partially over the IOL optic.⁵⁵⁵ However, the presence of a truncated sharp-edge IOL optic does carry an increased likelihood of undesirable optical phenomena after surgery.³⁴¹⁻³⁴³

Polishing of the anterior capsule has a variable effect on reducing PCO rates.^{549,556} However, anterior capsule fibrosis and contracture is more frequent with silicone than acrylic optic materials, and anterior capsule polishing may reduce this postoperative phenomenon.^{549,556,557} No difference in PCO rates has been found with prolonged administration of topical corticosteroids or topical NSAIDs.⁵⁵⁸⁻⁵⁶⁰

Posterior capsular opacification often occurs following ECCE by any method and can cause a gradual decrease in visual function. In a comparative study, the incidence of PCO was significantly higher at 1 year in the manual ECCE group than in the phacoemulsification group.²⁵⁰ The time of onset of PCO from the time of surgery varies.^{561,562} The frequency with which Nd:YAG laser capsulotomy is performed also varies, reported in the range of 3% to 53% within 3 years' time.²⁰¹ The Cataract PORT study reported a 19.2% incidence of PCO occurring within 4 months of cataract surgery.¹⁰² Well-designed clinical series with 3 to 5 year follow-up utilizing a sharp-edge optic design with either silicone or hydrophobic acrylic optics, typically show posterior capsulotomy rates between 0 and 4.7%.^{540,550}

Nd:YAG laser capsulotomy is an effective surgical procedure to clear the visual pathway and restore visual function, and to improve contrast sensitivity.⁵⁶³ The indication for performing Nd:YAG laser capsulotomy is PCO consistent with an impairment of vision to a level that does not meet the patient's functional needs or that critically interferes with visualization of the fundus.^[A:III] The decision to perform capsulotomy should take into account the benefits and risks of the laser surgery.^[A:III] The rate of posterior capsulotomy may be increased in patients with multifocal IOLs, presumably because these lenses reduce contrast sensitivity, which is further impaired by early PCO. Nd:YAG laser capsulotomy should not be performed prophylactically (i.e., when the capsule remains clear).^[A:III] Same-day bilateral Nd:YAG laser posterior capsulotomy may be appropriate when indicated.

Complications of Nd:YAG laser capsulotomy include transient and long-term increased IOP,⁵⁶⁴ retinal detachment, CME, damage to the IOL, hyphema, dislocation of the IOL, and corneal edema and corneal abrasions from using a focusing contact lens for the laser surgery. Axial myopia increases the risk of retinal detachment after Nd:YAG laser capsulotomy,⁵⁶⁵ as does pre-existing vitreoretinal disease, male gender, young age, vitreous prolapse into the anterior chamber, and spontaneous extension of the capsulotomy.⁵⁶⁶ In a study of eyes that underwent Nd:YAG laser capsulotomy after ECCE and implantation of sulcus-fixated IOLs, retinal detachment, CME, and new-onset glaucoma each occurred at a rate of approximately 1%.⁵⁶⁷ One to 8 years following uncomplicated phacoemulsification and capsular fixation of the IOL, two case series reported an incidence of retinal detachment of 0% to 0.4%.^{568,569} In one of these series, there were no retinal detachments in eyes with an axial length less than 24.0 mm.⁵⁶⁸ A case-control study found that, in the absence of a posterior capsule tear at the time of cataract surgery, subsequent Nd:YAG capsulotomy did not increase the risk of retinal detachment.⁵⁷⁰

In the absence of risk factors for IOP elevation, routine prophylaxis with ocular hypotensive agents at the time of capsulotomy is not consistently supported by the literature.^{571,572} However,

reduction of IOP has been demonstrated with topical brimonidine at the time of capsulotomy compared with a small rise of IOP in placebo-treated controls.⁵⁷³ In the presence of risk factors, such as pre-existing glaucoma or inflammation, a variety of agents to lower intraocular pressure have demonstrated efficacy at blunting IOP elevation.⁵⁷³⁻⁵⁷⁸ In addition to using these agents in high-risk patients, the surgeon should monitor the IOP at close intervals in the early postoperative period to modify the medication regimen if necessary.^[A:III]

Follow-up visits after Nd:YAG laser capsulotomy may vary in frequency, depending on the patient's condition and pre-existing comorbidities. The IOP of patients with significant optic nerve damage or without an IOL implanted within the capsular bag that provides a barrier to anterior migration of capsule debris, vitreous, etc., should be monitored after laser capsulotomy.^[A:III] Because retinal breaks or detachments are acute events that can occur weeks to years after laser capsulotomy, a routine dilated fundus examination is unlikely to detect retinal pathology that requires treatment in the absence of symptoms. All patients at increased risk of retinal detachment should be instructed to notify their ophthalmologist promptly if they have a significant change in symptoms, such as flashes of light, a significant increase in floaters, development of photopsias, loss of visual field, or decrease in visual acuity.^[A:III] If patients are familiar with the symptoms of retinal detachment, they may be more likely to report promptly after their onset, increasing the chances for successful surgical and visual results.⁵⁷⁹

PROVIDER AND SETTING

It is the unique role of the ophthalmologist who performs cataract surgery to confirm the presence of the cataract and to formulate and carry out a treatment plan.^[A:III] Diagnosis and management require expertise, skill, and specialized equipment. Clinical judgment and experience are necessary to weigh the medical, ocular, and psychosocial factors involved in deciding the appropriateness and timing of surgery.

The performance of certain diagnostic procedures (e.g., measurement of IOP, refraction, IOL power calculations) may be delegated to appropriately trained and supervised personnel. However, the interpretation of results and medical and surgical management of disease require the high degree of medical and surgical training, clinical judgment, and experience of the ophthalmologist.

Nearly all cataract surgery is performed in an outpatient setting, which may be in a hospital-based outpatient surgical facility or freestanding ambulatory surgery center. The surgical facility should comply with standards governing the particular setting of care (e.g., the Accreditation Association for Ambulatory Health Care, Inc., Joint Commission for Accreditation of Healthcare Organizations, American Hospital Association).^[A:III] Inpatient surgery may be necessary if there is a need for complex ocular care, multiple procedures, general medical and nursing care, or if there are multiple ocular conditions.

COUNSELING/REFERRAL

Patients with functionally limiting postoperative visual impairment should be referred for vision rehabilitation⁵⁸⁰ and social services.^[A:III]



APPENDIX 1. SUMMARY OF MAJOR RECOMMENDATIONS FOR CARE

DIAGNOSIS

Preoperative visual acuity is a poor predictor of postoperative functional improvement; therefore, the decision to recommend cataract surgery should not be made on the basis of visual acuity alone.^{1,2 [A:II]}

The patient should be asked specifically about near and distant vision under varied lighting conditions for activities that the patient views as important.^[A:III]

Ophthalmic Evaluation

The comprehensive evaluation (history and physical examination) includes those components of the comprehensive adult medical eye evaluation³ specifically relevant to the diagnosis and treatment of a cataract as listed below.

- ◆ Patient history,^[A:III] including the patient's assessment of functional status, pertinent medical conditions, medications currently used, and other risk factors that can affect the surgical plan or outcome of surgery (e.g., immunosuppressive conditions, sympathetic alpha-1a antagonists).
- ◆ Visual acuity with current correction (the power of the present correction recorded) at distance and when appropriate at near.^[A:III]
- ◆ Measurement of best-corrected visual acuity (with refraction when indicated).^[A:III]
- ◆ External examination (lids, lashes, lacrimal apparatus, orbit).^[A:III]
- ◆ Examination of ocular alignment and motility.^[A:III]
- ◆ Assessment of pupillary function.^[A:III]
- ◆ Measurement of intraocular pressure (IOP).^[A:III]
- ◆ Slit-lamp biomicroscopy of the anterior segment.^[A:III]
- ◆ Dilated examination of the lens, macula, peripheral retina, optic nerve, and vitreous.^[A:III]
- ◆ Assessment of relevant aspects of the patient's mental and physical status.^[B:III]

MANAGEMENT

Nonsurgical Management

At the present time, the highest quality evidence does not support a benefit from nutritional supplementation in preventing or delaying progression of cataracts; therefore, treatment with supplements is not recommended.^{4 [A:I]}

Patients who are currently smoking should be informed of the increased risk of cataract progression and the benefits of smoking cessation in retarding the progression of cataracts that have been demonstrated in several studies.^{5-7 [A:II]} Studies have found that smokers report that a physician's advice to quit is an important motivator in attempting to stop smoking.⁸⁻¹¹ Patients who are long-term users of oral or inhaled corticosteroids should be informed of the increased risk of cataract formation^{12-16 [A:II]} and may wish to discuss alternate medications with their primary care physician. Patients with diabetes mellitus should be informed of their increased risk of cataract formation.^{17-19 [A:II]} Brimmed hats and ultraviolet-B blocking sunglasses are reasonable precautions to recommend to patients.²⁰

Surgical Management

Indications for Surgery

- ◆ The primary indication for surgery is visual function that no longer meets the patient's needs and for which cataract surgery provides a reasonable likelihood of improved vision.^[A:III]
- ◆ Other indications for a cataract removal include the following:
 - ◆ Clinically significant anisometropia in the presence of a cataract.^[A:III]
 - ◆ The lens opacity interferes with optimal diagnosis or management of posterior segment conditions.^[A:III]
 - ◆ The lens causes inflammation (phacolysis, phacoanaphylaxis).^[A:III]
 - ◆ The lens induces angle closure (phacomorphic or phacotopic).^[A:III]

The ophthalmologist who is to perform the cataract surgery has the following responsibilities:

- ◆ To examine the patient preoperatively (see Ophthalmic Evaluation in the main text).^[A:III]
- ◆ To ensure that the evaluation accurately documents the symptoms, findings, and indications for treatment.^[A:III]
- ◆ To obtain informed consent from the patient or the patient's surrogate decision maker after discussing the risks, benefits, and expected outcomes of surgery, including anticipated refractive outcome and the surgical experience.^[A:III]

- ◆ To review the results of presurgical and diagnostic evaluations with the patient or the patient's surrogate decision maker.^[A:III]
- ◆ To formulate a surgical plan, including selection of an appropriate IOL.^[A:III]
- ◆ To formulate postoperative care plans and inform the patient or the patient's surrogate decision maker of these arrangements (setting of care, individuals who will provide care).^[A:III]
- ◆ To afford the patient or the patient's surrogate decision maker the opportunity to discuss the costs associated with surgery.^[B:III]

All patients undergoing cataract surgery should have a history and physical examination relevant to the risk factors for undergoing the planned anesthesia and sedation and as directed by a review of systems.^[A:III] For patients with certain severe systemic diseases (e.g., chronic obstructive pulmonary disease, recent myocardial infarction, unstable angina, poorly controlled diabetes, or poorly controlled blood pressure) a preoperative medical evaluation by the patient's physician should be strongly considered.^{21 [A:II]} Laboratory testing as indicated by the findings in the history and physical examination is appropriate.^{22 [A:I]}

Given the lack of evidence for an optimal anesthesia strategy during cataract surgery, the type of anesthesia management should be determined by the patient's needs and the preferences of the patient and surgeon.^{23 [A:II]}

Use of a 5% solution of povidone iodine in the conjunctival cul de sac is recommended to prevent infection.^{24,25 [A:II]}

Further management recommendations are in the main body of the text.

Postoperative Follow-up

The frequency of postoperative examinations is based on the goal of optimizing the outcome of surgery and swiftly recognizing and managing complications. Table 7 provides guidelines for follow-up based on consensus in the absence of evidence for optimal follow-up schedules.

Patient Characteristics	First Visit	Subsequent Visits
Without high risks or signs or symptoms of possible complications following small-incision cataract surgery	Within 48 hours of surgery	Frequency and timing dependent upon refraction, visual function, and medical condition of the eye
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Patients should be instructed to contact the ophthalmologist promptly if they experience symptoms such as a significant reduction in vision, increasing pain, progressive redness, or periocular swelling, because these symptoms may indicate the onset of endophthalmitis.^[A:III]

In the absence of complications, the frequency and timing of subsequent postoperative visits depend largely on the size or configuration of the incision; the need to cut or remove sutures; and when refraction, visual function, and the medical condition of the eye are stabilized. More frequent postoperative visits are generally indicated if unusual findings, symptoms, or complications occur, and the patient should have ready access to the ophthalmologist's office to ask questions or seek care.^[A:III]

Components of each postoperative examination should include.^[A:III]

- ◆ Interval history, including use of postoperative medications, new symptoms, and self-assessment of vision.
- ◆ Measurement of visual function (e.g., visual acuity, pinhole testing).
- ◆ Measurement of IOP.
- ◆ Slit-lamp biomicroscopy.

- ◆ Counseling/education for the patient or patient's caretaker.
- ◆ Management plan.

A final refractive visit should be made to provide an accurate prescription for spectacles to allow for the patient's optimal visual function.^[A:III]

PROVIDER AND SETTING

It is the unique role of the ophthalmologist who performs cataract surgery to confirm the presence of the cataract and to formulate and carry out a treatment plan.^[A:III] The surgical facility should comply with standards governing the particular setting of care (e.g., the Accreditation Association for Ambulatory Health Care, Inc., Joint Commission for Accreditation of Healthcare Organizations, American Hospital Association).^[A:III]

COUNSELING/REFERRAL

Patients with functionally limiting postoperative visual impairment should be referred for vision rehabilitation²⁶ and social services.^[A:III]

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APPENDIX 2. VALUE OF CATARACT SURGERY

Methods to evaluate whether the cost of a health care intervention is a good use of available resources include cost-effectiveness or cost-utility calculations. While cost-effectiveness analyses use monetary terms, cost-utility analyses include the value that a patient places on the quality of additional years of life, using a measure called the quality-adjusted life year (QALY). The QALY is a generic outcome measure of the improvement in quality and quantity of life after a health care intervention and so enables comparison of the value of interventions for different health conditions.^{123,581} In calculating the QALY, researchers use the economic technique of discounting to reflect the time-value of money because the effect gained from the dollars spent on the treatment remains over the course of the lifetime of the patient.^{582,583} The lower the amount calculated for a QALY, the better the value of the intervention. A further refinement incorporates other parameters to describe value-based medicine analyses.⁵⁸⁴

In a study in Sweden and a study in the United States, the hypothetical cost per QALY gained for cataract extraction in one eye was estimated respectively at US \$4,500¹²⁴ and US \$2,023.¹²⁵ In a US study, the estimated cost per QALY gained for cataract surgery in the second eye was US \$2,727 (calculated in 2003).¹²⁶ These values for cataract surgery compare favorably with those reported for other ophthalmic procedures (e.g., laser photocoagulation for diabetic macular edema, \$3,101¹²⁷; laser photocoagulation for extrafoveal choroidal neovascularization, \$23,640).¹²⁸

For comparisons outside of ophthalmology, the cost-utility in other areas of medicine have been calculated as follows: single-vessel coronary artery bypass surgery for disease of the left anterior descending artery costs \$7,000/QALY¹²⁷; treatment of systemic arterial hypertension (diastolic 95-

103 mmHg in males aged 40) costs \$58,000/QALY; and ambulatory peritoneal dialysis costs \$90,000/QALY.

A review of technological innovation looked at the costs and benefits of several treatments for disease conditions, including heart attack, low birthweight infants, depression, breast cancer, and cataracts.⁵⁸⁵ The authors concluded that expansion in treatment for patients operated at much less severe measures of visual acuity than in the past is almost certainly beneficial and that there have been substantial improvements in quality at no cost increase per patient. The present value of cataract surgery was estimated at \$95,000, which is much greater than the estimated costs of \$2,000 to \$3,000. Thus, the benefits of expanded cataract treatment exceed the costs. This compares well with the present value estimated for the other treatments: \$20,000 for breast cancer; \$6,000 for depression, \$240,000 per low birthweight infant, and \$70,000 for heart attack.



LIST OF ABBREVIATIONS

- ADVS:** Activities of Daily Vision Scale
AMD: age-related macular degeneration
ASCRS: American Society of Cataract and Refractive Surgery
BCVA: best-corrected visual acuity
CME: cystoid macular edema
D: diopter
ECCE: extracapsular cataract extraction
HEMA: hydroxy ethyl methacrylate
IFIS: intraoperative floppy iris syndrome
IOL: intraocular lens
IOP: intraocular pressure
IV: intravenous
Nd:YAG: neodymium: yttrium-aluminum-garnet laser
NEI-VFQ: National Eye Institute-Visual Function Questionnaire
NEON: National Eyecare Outcomes Network
NSAID: nonsteroidal anti-inflammatory drug
OVD: ophthalmic viscosurgical device
PCO: posterior capsular opacification
PMMA: polymethyl methacrylate
PORT: Patient Outcomes Research Team
PPP: Preferred Practice Pattern
PSC: posterior subcapsular
QALY: quality-adjusted life year
VF-14: Visual Function Index



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