

# Age-related vision loss: cataract

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Cataract is a major cause of vision loss in the aging population, impacting on patients' quality of life and affecting their ability to engage and interact with their environment, as well as function independently. This review addresses issues regarding age-related cataract and its management, with a focus on those issues important to the nonophthalmologist. This includes the pathogenesis of cataracts, common referral criteria and basic aspects of surgical management, including complications, types of anesthesia and the use of different intraocular lenses. Good communication between the referring physician and cataract surgeon is key to optimizing surgical outcomes by identifying systemic comorbidities at the time of diagnosis that require management prior to elective surgical intervention, and to reduce the risk of both ocular and nonocular complications.

Vision is the primary sense allowing engagement and interaction with our environment, facilitating independent functioning and life quality. In older age and with increasing frailty, losing vision has a major negative impact on the individual, their carers and the community involved in care support. Cataract is a major cause of sight loss in older age [1] and this review will describe the pathogenesis, symptoms, signs and management of cataract, highlighting issues that are of particular relevance in sharing care between the referring physician and eye surgeon. Imparting information to patients relating to surgery and including a primary risk assessment, including systemic comorbidity, allows realistic expectations to be set prior to referral and safe surgery. In more affluent countries where surgical services are easily accessible, the threshold for cataract extraction is markedly lower than in previous years, which is a stark contrast to the lamentable situation in developing countries where cataract remains a major cause of blindness.

## Pathogenesis

Crystalline lens transparency relies on a regular arrangement on cellular organization and fibril structure within the lining capsule. New lens fibers are added to the central core or nucleus of the lens that contains the chronologically oldest lens fibrils. With metabolic or biochemical insult, loss in fibril arrangement and transparency may occur, resulting in a focal or diffuse opacity, which, in the early stages, may or may not have a measurable effect on vision [2]. This opacification in the natural lens is termed a cataract and while there are no reliable methods for predicting progression, risk factors for specific cataract types based on anatomic morphologies have been identified. For example, cataract located in the center of the lens (i.e., nuclear) is associated with smoking [3], the posterior plane

(i.e., posterior subcapsular) is associated with diabetes and use of corticosteroids [4], and the periphery (i.e., cortical) is associated with ultraviolet exposure [5]. The type of cataract may be detected with a direct ophthalmoscope or slit lamp as a black silhouette against the red glow of reflected light from the vascular fundus of the eye. Alteration in crystalline protein structure, function and fibril arrangement, accumulation of chromophore pigments and vacuoles are characteristics of the aging lens. Progressive cataract is associated with poor health and life survival and a history of poor nutrition and dehydration [6], alcohol consumption [7], exposure to ionizing radiation and corticosteroid use [8], as well as a number of common medical comorbidities including diabetes [9,10], cardiovascular disease [11] and renal disease [12]. Moreover, income (or education) was inversely related to the 10-year cumulative incidence of nuclear cataract in a population-based longitudinal epidemiologic study [13]. Younger individuals with cataract may have a positive family history and other features of associated conditions; for example, myotonic dystrophy, Down's syndrome, familial Danish dementia or Wilson's disease [14]. Whether or not detailed observations of the human crystalline lens could reflect changes in other organs and could be used as a window on brain functioning is the subject of ongoing research.

## Reason for referral

Symptoms arising from cataract impact on patients' lives in a myriad ways, ranging from very subtle effects on visual quality to bilateral blindness depending on the stage of lens opacification. As light passes from the pupil to the lens, imperfections in optical transparency translate into intraocular light scatter and glare [15]. This symptom may be most noticeable with certain environmental factors; for example, a low

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setting sun or when looking at oncoming car headlights while driving at night. Reduced contrast sensitivity associated with cataract may lead to increasing problems reading grey text on a less-than-white background, often the case with newsprint [16]. On the other hand, the refractive shift to myopia induced by a hardening of the lens nucleus may be welcomed by patients who may be able to read small print without reading glasses, much to their surprise. Progression of cataract symptoms is variable and may not affect quality of life for months or even years from diagnosis. When activities of daily living become difficult owing to cataract-related visual impairment the question of cataract surgery should be considered [17]. The lifestyle needs that trigger referral to an eye surgeon often relate to meeting the legal requirement for driving, misjudging distances and depths, recognizing faces and bus numbers, reading computer displays and frustration with hobbies, such as being unable to spot a lost golf ball. Referral to an eye surgeon is indicated if the patient's symptoms are affecting their visual quality and lifestyle to the point where the patient is willing to undergo surgery [18]. In some countries the optometrist or optician plays a key role in cataract symptom detection and initiates the referral process. The days of waiting for a cataract to 'mature' or be 'ready for removal' are long gone and treatment is now driven by the patients' subjective visual experience with less regard for a visual acuity-based criterion [19]. The referring physician is best placed to provide the medical data necessary to optimize surgical outcomes and engage in a preliminary discussion on surgical care, focusing on benefit and risk.

Good communication between the referring physician and cataract surgeon is key to good quality care. Identifying occult medical disorders at the time of cataract diagnosis, most commonly diabetes mellitus, requires management prior to elective surgical intervention in order to reduce the risk of both ocular and nonocular complications. Similarly, the management of systemic hypertension extends beyond cataract care. It is also important to note any history of chronic obstructive airway diseases, including bradycardia, asthma and any known drug allergies that would help in planning and delivering patient care. Finally, the referring physician might use the opportunity of the cataract diagnosis to emphasize the importance of smoking cessation, which poses a risk for irreversible blindness and extraocular morbidity and mortality.

### Which eye for surgery?

Should a patient with bilateral cataract opt for an operation, most cataract surgeons advise sequential surgery, whereby the eye with worst vision is operated on first. Bilateral simultaneous surgery carries a real risk of complications affecting both eyes, negating any perceived benefits of convenience or cost. Nevertheless, several studies have reported that simultaneous bilateral cataract surgery by experienced surgeons could be a safe and efficient procedure and is positively received by patients [20,21]. In the event of comorbidity, for example macular degeneration or glaucoma, the visual outlook may be limited, especially in the eye with poorest vision. Under these circumstances it may be legitimate to operate on the eye with best visual potential even if this is the eye with better preoperative vision, although under these circumstances the surgical stakes are higher.

### Risks of surgery

The vast majority of patients undergoing cataract surgery will have a successful outcome. However, the risk of complications needs to be discussed in the light of coexisting eye and systemic comorbidities so that informed consent is relevant, consistent and fully understood. This process is best initiated at the point of referral. While the risk of a blinding complication (e.g., a catastrophic choroidal hemorrhage or aggressive intraocular infection) is extremely low, sight loss arising from a breach in the posterior capsule, published series demonstrate that macular edema or a failing corneal endothelium occurs in single-figure percentage frequencies. Patients who are short-sighted are at particular risk of retinal detachment when vitreous gel escapes from the eye through a torn posterior capsule [22]. In addition, diabetes predisposes to macular edema [23], and patients with shallow anterior chambers, typically associated with hypermetropia, may have a compromised 'dystrophy' affecting their corneal endothelium. The small, but finite, risks of surgery encourage most surgical practitioners to advise that one eye, usually the eye with the worst vision, be operated on first rather than suggesting that bilateral simultaneous surgery be carried out for fear of complications, such as severe infection, which could potentially affect both eyes. Exceptions to this rule may be considered if patients that may require a general anesthetic present with very advanced bilateral cataracts. This may arise in a patient with dementia unable to comply with a local anesthetic procedure, where the risks of two general anesthetics outweigh the benefits of separate procedures [24].

### Anesthesia & surgery for cataract

Most patients undergoing surgery will have local anesthesia, either with a periocular injection or topically applied surface anesthetic, sometimes combined with direct intraocular irrigation of preservative-free anesthetic agent [25]. The latter is an option providing there is good co-operation in maintaining patient fixation, despite the bright light of the operating microscope. Patients who are anxious may benefit from sedation and the calming influence of medical and nursing staff [26]. However, maintaining a stationary position beneath the surgical drapes may be just as challenging for a patient with kyphosis, arthritis, respiratory compromise, dementia and claustrophobia as for the surgeon attempting to operate on a mobile eye target with movements magnified through the operating microscope. It is therefore important to discuss with the patient at the preoperative assessment whether he/she can lie down flat for approximately 30 min during cataract surgery.

### Surgery

Cataract extraction and intraocular lens (IOL) implantation is the most commonly performed elective surgical procedure reflecting the favorable cost-effectiveness of the procedure. The relatively low surgical risk relates to the evolution of microsurgical techniques to a point where both cataract removal and IOL implantation may be achieved through an incision measurable in millimeters. A well-constructed wound can be placed in a location in the cornea to reduce pre-existing astigmatism [27], and permit insertion of a folded IOL, which opens inside the eye much like 'a ship in a bottle', yet similar to a one-way valve, self-seals and therefore requires no sutures. The IOL rests on the posterior capsule of the crystalline lens, deliberately left undisturbed after removing the dense bulk of the cataractous lens by an ultrasound 'phakoemulsification' probe. This is the microsurgical equivalent to a jackhammer, which the surgeon holds poised between two single cell layers that should not be damaged; namely, the corneal endothelium, which maintains corneal transparency, and the posterior capsule, which both protects the underlying vitreous gel from surgical damage, and ensures IOL support. Current techniques are a far cry from the approach used up until the final decades of the last century whereby the cataract was removed complete with capsule through an incision extending half way around the cornea, often followed by vitreous gel and always requiring sutures. Prior to the routine

use of IOLs, the optical focus of the eye would require high convex aphakic spectacles postoperatively, the thick glasses framing the stereotypical facial phenotype of the older generation.

### Intraocular lenses

Successful optical rehabilitation relies on calculating the correct power of the prosthetic lens, which is determined preoperatively by biometric measurement. The power calculation is based on the length of the eyeball measured by ultrasound and the curvature of the cornea. These data are used to match the focal point of the eye with the plane of the macula for a monofocal IOL. For most patients, the aim is to improve distance vision with less reliance on spectacles, although predicting a different focus for patients is possible depending on their pre-existing refractive error and their visual requirements. Most patients with a monofocal IOL implanted after cataract surgery will need spectacles for reading unless one eye has a new focus intentionally set for near-work activities. New types of implant include multifocal IOLs and those that have the capability to mimic the accommodation property of the youthful crystalline lens [28]. However, more detailed clinical evaluation is required on performance and long-term efficacy before they supersede monofocal IOLs in public sector surgery. While IOLs have transformed the success of cataract surgery, the optics of the central optical zone and the support structure of the posterior capsule does lead to limitations. Troublesome glare and arcs of light reminiscent of the visual aura in migraine arising from unwanted reflections at the edge of the implant may give rise to various symptoms with severity ranging from a mild nuisance to a disability, occasionally requiring IOL exchange. More common is the experience of difficulties while driving at night when nocturnal pupil dilatation to a diameter larger than the IOL optic leads to starburst and dazzling glare disability. Therefore, patients requesting cataract surgery purely for improved night driving safety should be informed that their cataract-related symptoms may merely be replaced by IOL-related symptoms postoperatively. The posterior capsule upon which the IOL rests is prone to developing opacification from proliferation of lens epithelial cells behind the IOL, leading to symptoms similar to cataract. This is one of the most common complications often arising several years following surgery; fortunately, it is easily treated by Nd:YAG laser capsulotomy, delivered without the need for anesthesia at the slit-lamp [29,30].

### Referral for surgery

The detail of the eye examination is likely to be captured in the optometrist evaluation, which in many cataract care pathways is forwarded directly to the cataract surgical unit; however, without the physician's input it is not possible to provide optimal cataract care.

### Medical considerations

Medical considerations that influence cataract surgery are considered according to whether they impact on the preoperative preparation, surgical technique or postoperative care, each of which requires planning in order to optimize outcomes. Overlooking any of these factors may result in a potentially avoidable complication and visual loss, the most serious being intraocular infection, known as endophthalmitis [31]. The referring physician should assess high risk for this complication by an 'ABCD' routine:

- A: Ask about symptoms of discharge and irritation in and around the eyelids;
- B: Blepharitis and rosacea are indicated by crusts and scales at the lashes;
- C: Corneal clouding and peripheral blood vessels is a sign of marginal ulceration;
- D: Duct obstruction and lacrimal sac pus can be detected by pressing at the inner canthus to elicit reflux from the lower punctum.

When present, these may be signs of infection that may be asymptomatic. The presence of these features requires specific treatment or antibiotic prophylaxis prior to surgical assessment. External eye infections with coexisting poor tear film quality are most marked among patients with specific medical conditions associated with cataract (e.g., Down's syndrome and Parkinson's disease) [32].

Medical comorbidities that have a bearing on cataract care have relevance to both eye and to general management, the details of which should be included in referrals for cataract surgery. The most common amongst these are summarized in the 'EFGH' list below:

- E: Endocrine abnormalities, most commonly diabetes mellitus, are associated with cataract and retinopathy. Uncontrolled diabetes precludes surgery, which may result in a number of avoidable risks affecting wound healing, intraocular inflammation, macula edema and progressive retinopathy [33];
- F: Flomax™ (tamsulosin) is frequently prescribed for urinary incontinence and has a

profound effect on the behavior of the iris during cataract surgery through its anticholinergic properties producing 'floppy iris syndrome'. This is managed during surgery by hooking back the pupil margin with micro-hooks to prevent iris prolapse [34];

- G: Growth hormone use poses a potential variant Creutzfeldt-Jakob disease risk, as does a history of neurosurgery using dura mater tissue [35];
- H: Hypertension, if uncontrolled, poses surgical risks of bleeding ranging from mild subconjunctival hemorrhage to a catastrophic suprachoroidal hemorrhage expelling all intraocular contents during surgery [36]. This possibility increases with the use of anticoagulants that needs to be maintained within therapeutic levels, especially warfarin [37].

### Cataract controversies & research

The advances in microsurgical techniques, ocular biometry and IOL design have all contributed to the safety and effectiveness of cataract surgery, although a number of controversies have yet to be resolved. Two areas of current cataract research relate to nonsurgical management and the relevance of IOL spectral transmission influences on circadian rhythm regulation.

While a number of reports suggest the potential of acetyl carnosine in reversing cataract, further work to develop novel, validated tools to detect biochemical and optical change in the human crystalline lens is needed to demonstrate the efficacy of a pharmacologic agent in reversing early lens opacity. Carnosine acts as a competitive inhibitor of the nonenzymatic glycosylation of proteins and it has been suggested that carnosine may potentially reverse the formation of the advanced glycation end-products relevant in cataract pathogenesis [38]. It is unlikely that a nonsurgical approach would reverse advanced structural alteration in lens fiber arrangement associated with more advanced cataract, although animal studies suggest a possible therapeutic role earlier in the natural history of cataract [39]. However, it would need to be demonstrated that continued dosing leads to long-term lens transparency and is cost effective in large population studies before this approach is widely adopted as a therapeutic option. Nevertheless, considering the increasing age-related prevalence and impact on quality of life even in early stages of cataract, exploring nonsurgical strategies in cataract is warranted [40].

With regard to the spectral transmission of IOLs, sunlight exposure, especially blue light spectral components, are most efficient in retinal ganglion-mediated melatonin suppression effects. This has a downstream impact on a number of physiological functions related to homeostasis, mood, cognition and functional performance [41]. Age-related reduction in both pupil size and human crystalline lens light transmission reduce the level of retinal illumination. The transmittance spectra of IOLs has attracted interest in the light of evidence for the role of blue light both in mediating and maintaining circadian rhythm control and as a possible trigger for macular degeneration supported by laboratory studies. The current practice of using blue-blocking IOLs for photoprotection may alleviate concerns about this possibility; however, the potential for circadian rhythm disruption remains. It has been suggested that a clinical approach to reconcile both issues may be to use violet rather than blue light blocking IOLs and instruct patients to wear sunglasses in bright sunlight following cataract surgery and IOL implantation [42].

The longer-term effects on the eye and general health using different IOL filters is awaited with interest.

### Conclusion & future perspective

In summary, cataract is a major cause of visual loss among the older age group worldwide, and, at present, cataract surgery is the most commonly performed elective surgical procedure in developed countries. Imparting information to patients relating to surgery and performing a primary risk assessment of systemic comorbidities is of paramount importance. Interestingly, cataract has been demonstrated to be associated with some measures of frailty, including slower gait time, lower peak expiratory flow rate and weaker handgrip strength, independent of visual acuity and systemic comorbidities [43]. Therefore, it is possible that age-related cataract may be an indicator of general functional decline in older adults. In the developing world, where economic factors and the lack of cataract surgeons make surgery a less realistic option, prevention may be the only pragmatic global approach and funds should be directed towards its realization [44].

#### Executive summary

##### **Vision & old age**

- Cataract is a major cause of sight loss in older age and has a major negative impact for the individual, their carers and the community involved in care support.

##### **Reason for referral**

- Referral to an eye surgeon is indicated if the patient's symptoms are affecting their visual quality and lifestyle to the point where the patient is willing to undergo surgery.

##### **Which eye for surgery?**

- Normally, most eye surgeons would advise sequential cataract surgery whereby the eye with worst vision is operated on first.

##### **Risks of surgery**

- The vast majority of patients undergoing cataract surgery will have a successful outcome, while the risk of a blinding complication is approximately 1:1000.

##### **Anesthesia & cataract surgery**

- Most patients undergoing cataract surgery will have local anesthesia, either with a periocular injection or topically applied surface anesthetic.

##### **Surgery**

- A self-sealing corneal wound is constructed, the dense bulk of the cataractous lens is removed with an ultrasound probe leaving the posterior capsule deliberately undisturbed and a folded intraocular lens is inserted, opening inside the eye much like 'a ship in a bottle' and resting on the posterior capsule.

##### **Intraocular lenses**

- The commonly used monofocal intraocular lens aim to improve distance vision with less reliance on spectacles, although most patients will still need spectacles for reading unless one eye has a new focus intentionally set for near work activities.

##### **Medical considerations**

- Medical comorbidities that have a bearing on cataract care include endocrine abnormalities (most commonly diabetes), Flomax™ (tamsulosin) use, growth hormone use and hypertension.

##### **Cataract controversies & research**

- Acetyl carnosine acts as a competitive inhibitor of the nonenzymatic glycosylation of proteins and may potentially reverse the formation of the advanced glycation end-products relevant in cataractogenesis.

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The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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