

Cataract

Lens pathology, morphology, and clinicopathologic correlations

An anterior-segment pathology lecture

Dr Abu Suraih Sakhri

MBBS, MD (Pathology)

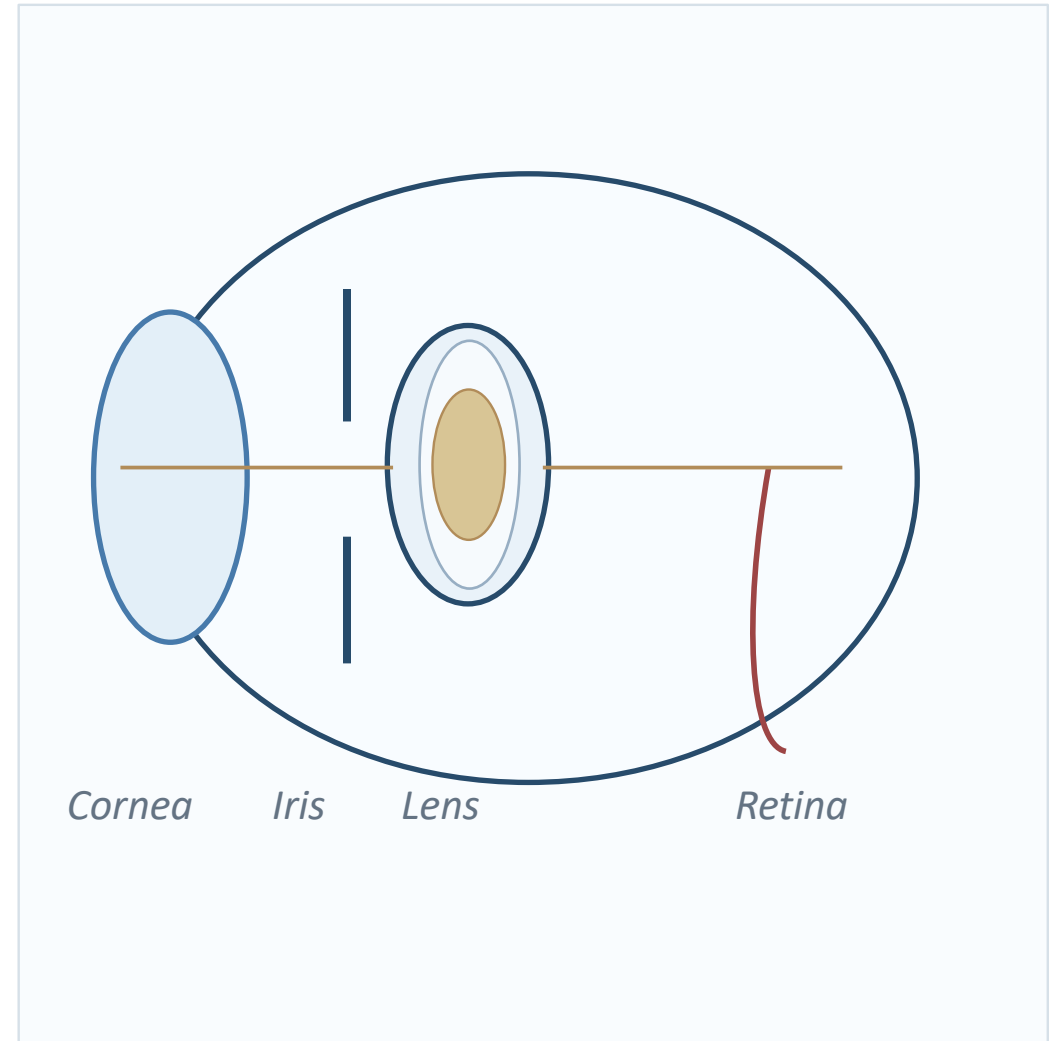
www.abusuraihsakhri.com

Learning objectives

- Localize the lens anatomically and explain how loss of transparency impairs vision.
- Distinguish nuclear, cortical, posterior subcapsular, and anterior subcapsular cataracts.
- Connect aging, metabolic disorders, exposure, and inflammation with distinct lens changes.
- Interpret surgical principles and selected causes of persistent or recurrent visual blur.

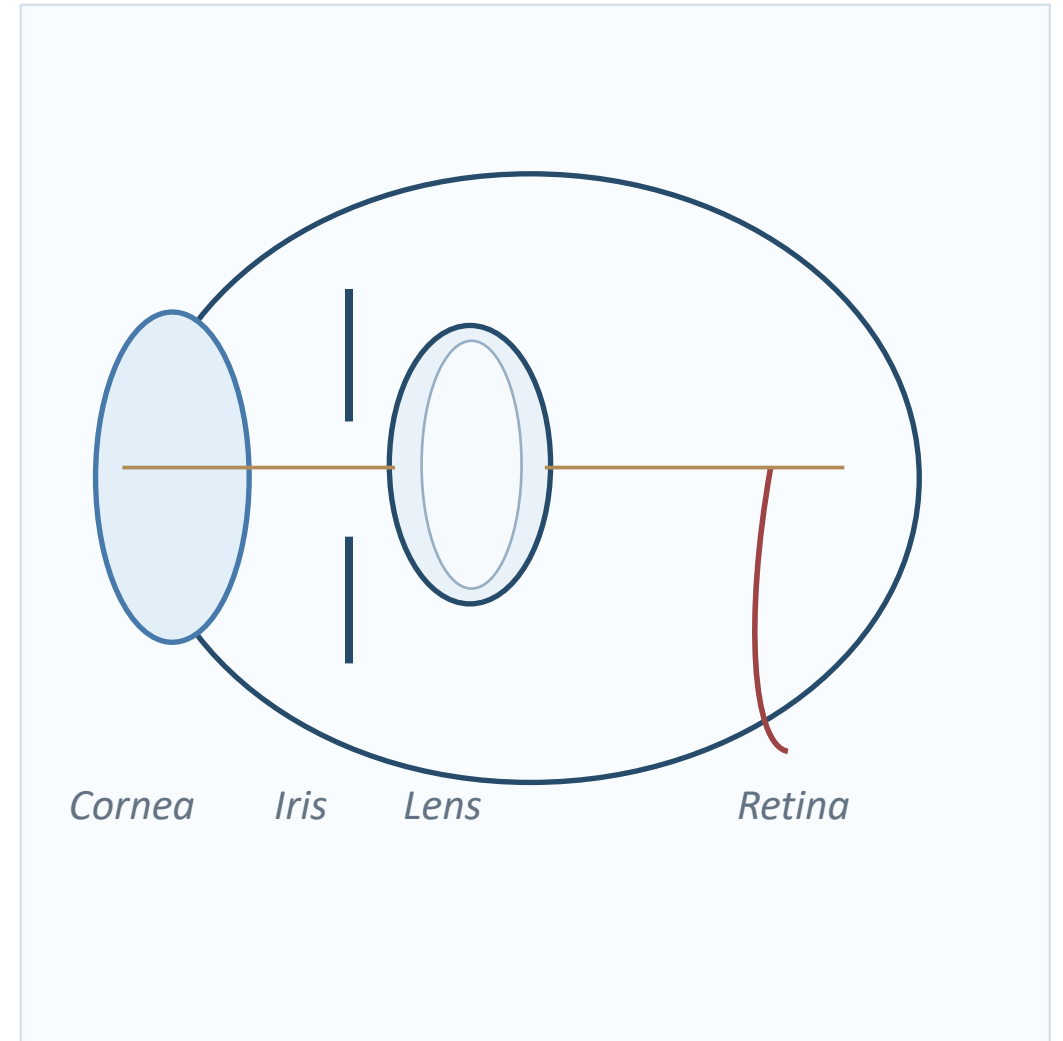
What is a cataract?

- A cataract is an opacity within the crystalline lens, rather than a corneal or retinal lesion.
- Opacities may be congenital or acquired and may affect distinct lens compartments.
- Opacity impedes transmission of a focused image to the retina; Anatomical location helps explain the clinical effects.



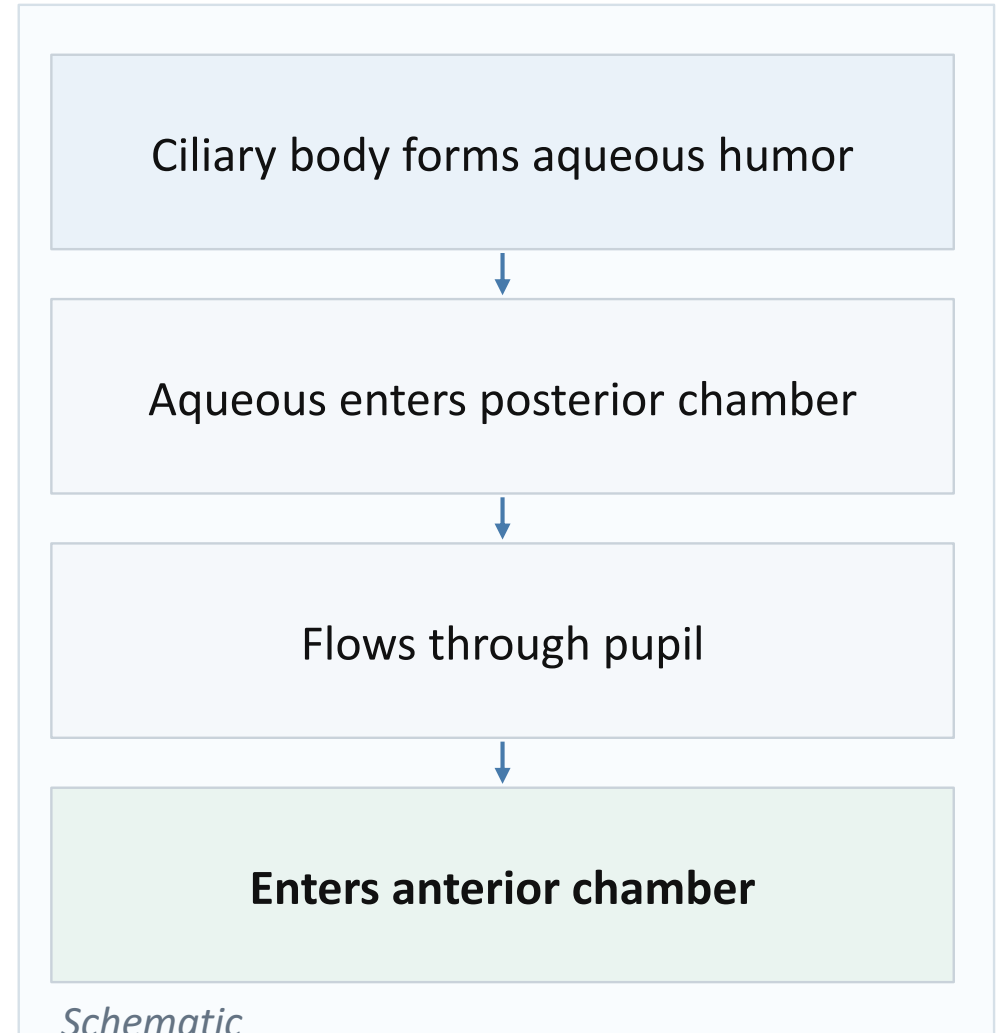
Optical pathway and anatomical localization

- Light passes through cornea, aqueous humor, pupil, crystalline lens, and vitreous before reaching the retina.
- That the cornea—not the lens—is the eye's principal refractive surface.
- The lens fine-tunes focus; Its opacification reduces retinal image quality even when the cornea is clear.



The chambers surrounding the lens

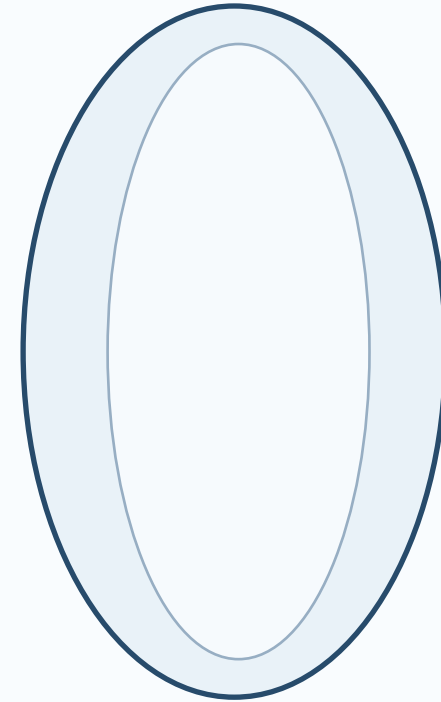
- The anterior chamber lies between cornea and iris; Aqueous humor circulates through this space.
- The posterior chamber is bounded by iris anteriorly and lens posteriorly.
- The ciliary body produces aqueous humor, which passes through the pupil to the anterior chamber.



The lens is a closed epithelial system

- A continuous basement membrane—the lens capsule—encloses the lens.
- Lens epithelial cells and their derivative fibers remain within the capsule rather than exfoliating.
- This unusual confinement influences aging changes, lens enlargement, and surgical technique.

Schematic · lens section



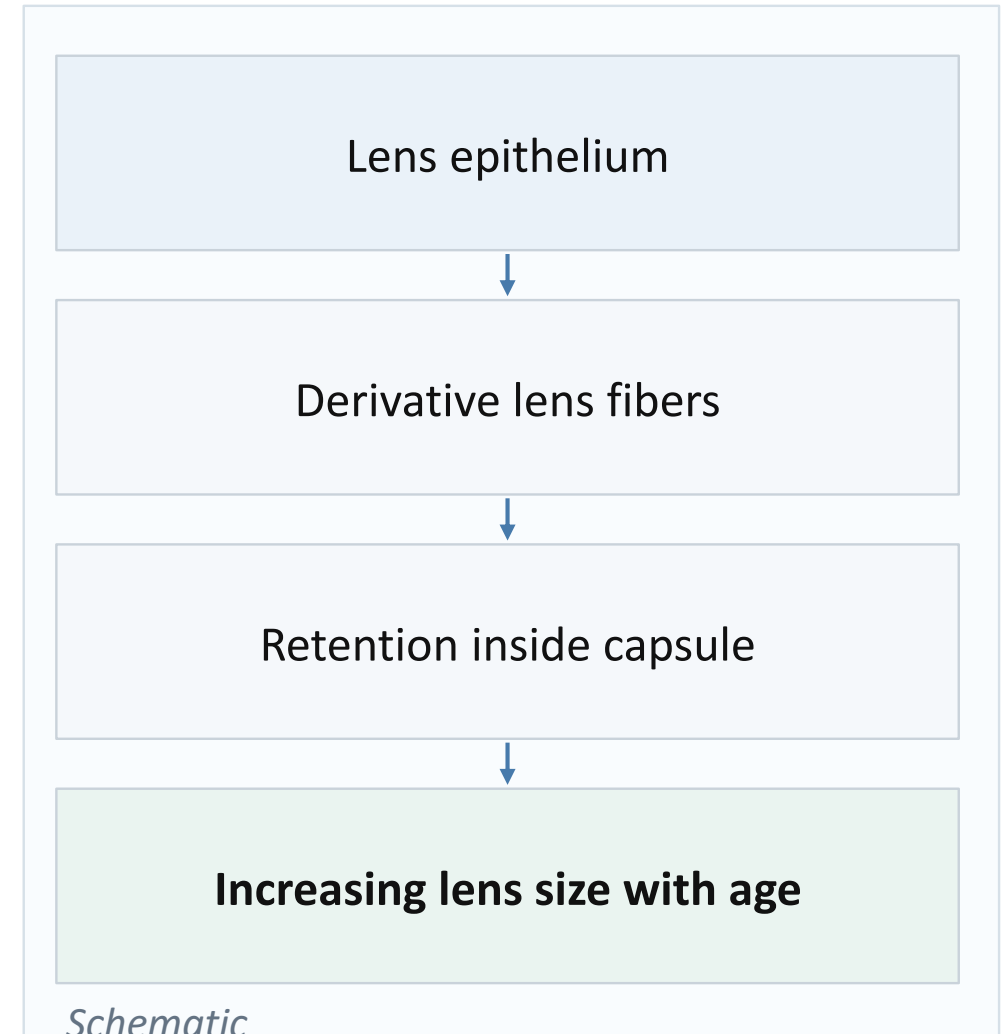
Anterior

Posterior

Capsule surrounds a lens that retains its cells and fibers.

Lens epithelium and fiber accumulation

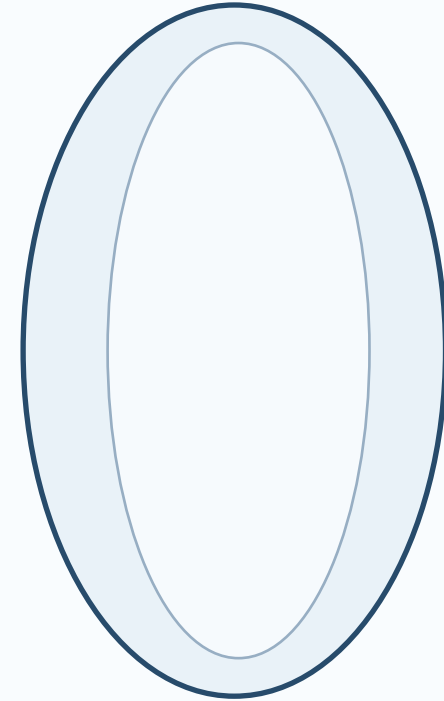
- Lens epithelial cells give rise to differentiated lens fibers.
- New cellular and fiber material accumulates within the capsular boundary— as infoliation.
- This persistent accumulation contributes to enlargement of the lens with age.



Recognizing lens compartments

- The nucleus occupies the central region; Cortex lies peripherally beneath the capsule.
- The anterior capsule overlies the anterior epithelial layer; Posterior capsule bounds the back of the lens.
- Location provides the morphological vocabulary: Nuclear, cortical, or subcapsular opacity.

Schematic · lens section



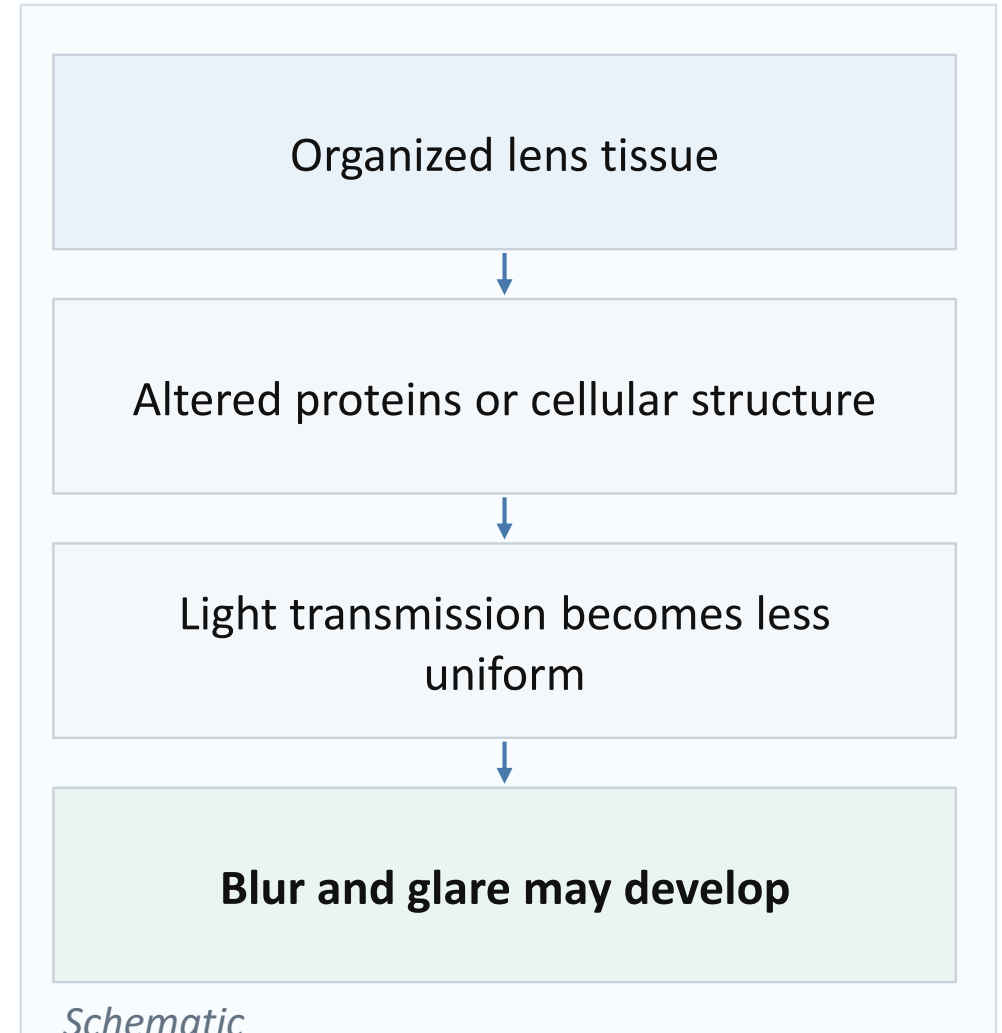
Anterior

Posterior

Nucleus central · cortex peripheral · capsule external

What transparency requires

- The normal lens transmits light through organized, clear lens tissue.
- Disrupted lens protein organization or altered cellular architecture can scatter incident light.
- Cataract is therefore an optical consequence of a structural alteration, not synonymous with retinal degeneration.



Why opacity changes vision

- An opaque lens reduces the quality of the optical image delivered to photoreceptors.
- Patients may describe blurred vision, glare, halos, or faded colors.
- Different mechanisms can produce similar symptoms; Ocular examination localizes the responsible lesion.

Transmission

Less useful image-forming light reaches the retina.

Scattering

Stray light can increase glare and reduce contrast.

Color

Yellow–brown lens pigments alter color perception.

Age-related versus non–age-related cataract

- Age-related cataract is common and typically has a gradually evolving lens opacity.
- Other cataracts occur in children, after injury, with systemic disease, or after exposure to drugs or radiation.
- Age at onset and medical history help target the etiologic differential.

Age-related

Progressive changes in lens proteins and compartments

Congenital/pediatric

Present from birth or during childhood

Secondary/acquired

Systemic disease, exposure, trauma, ocular inflammation

Etiologic framework for cataracts

- Systemic illnesses, corticosteroids, radiation, trauma, and intraocular disorders as associations.
- Metabolic, inflammatory, toxic, and physical mechanisms need not affect identical lens compartments.
- More than one exposure or mechanism may coexist in the same patient.

Systemic

Galactosemia · diabetes · Wilson disease · atopic dermatitis

Exposure

Corticosteroids · radiation

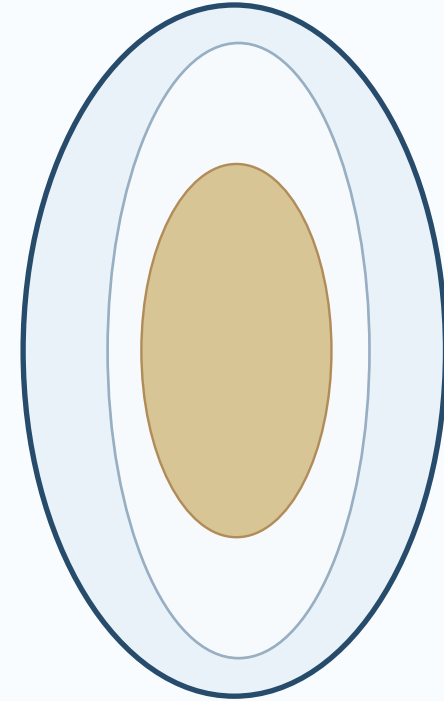
Local ocular

Trauma · intraocular disease · inflammation

Nuclear sclerosis: The age-related prototype

- Age-related cataract commonly develops from opacification of the lens nucleus.
- The nucleus progressively changes its optical and physical properties.
- Nuclear sclerosis is an anatomical morphological diagnosis; Other cataract types may coexist.

Schematic · lens section



Anterior

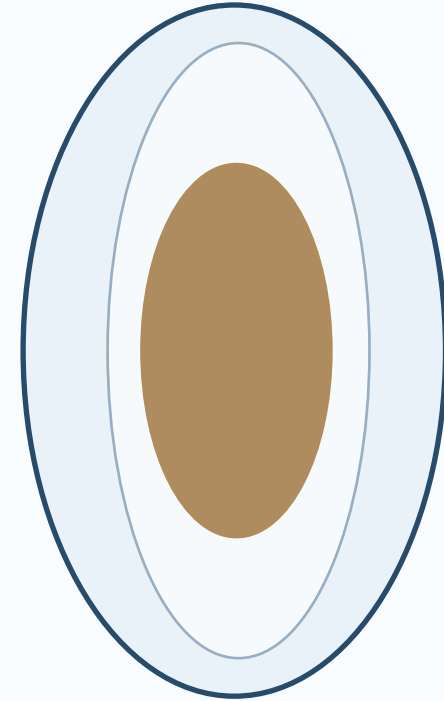
Posterior

Central nuclear change is the defining compartment.

Yellow–brown nuclear discoloration

- The aging lens nucleus can acquire urochrome pigment and become yellow or brown.
- Nuclear discoloration is accompanied by changes in the character of transmitted light.
- Nuclear color should be interpreted alongside opacity and visual function—not as a standalone grading cut-off.

Schematic · lens section



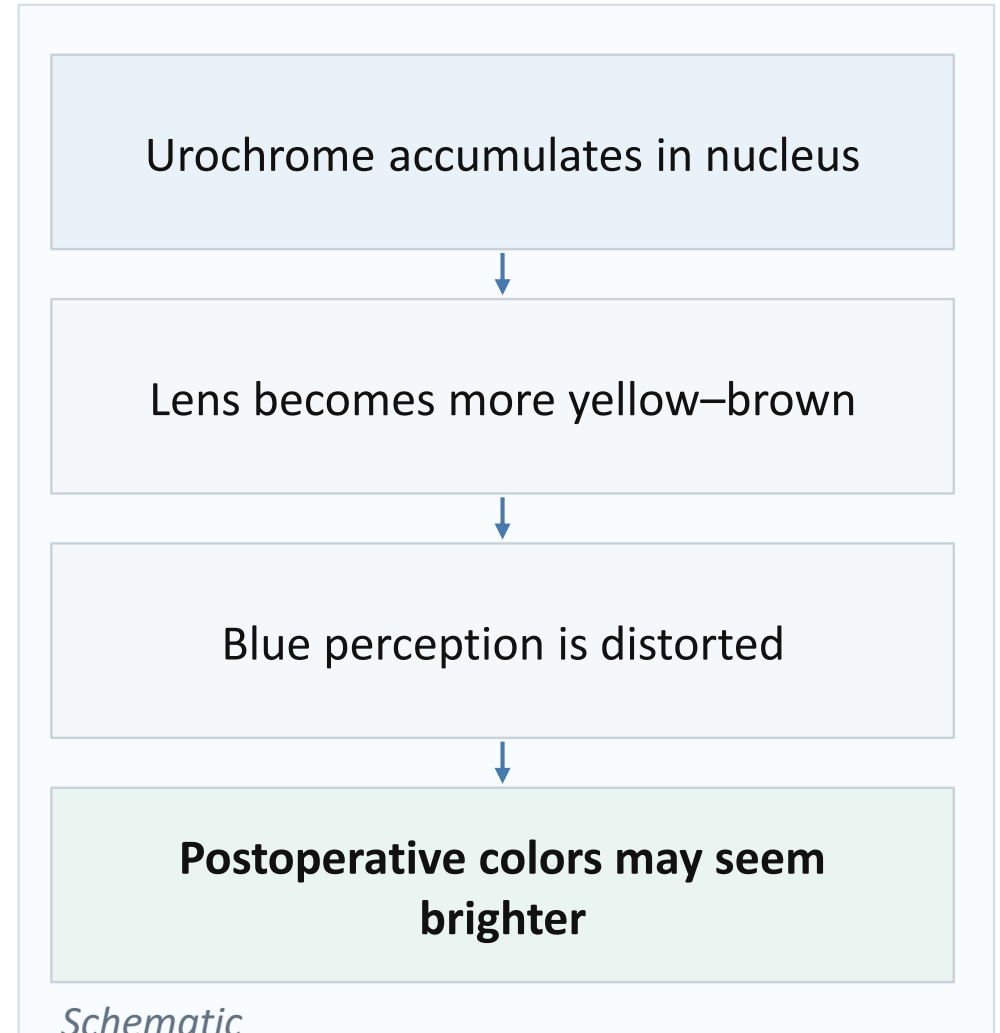
Anterior

Posterior

Pigmented nucleus · illustrative coloration
only

Color perception in nuclear cataract

- A yellow–brown nucleus disproportionately alters the transmission of shorter-wavelength light.
- Patients may report that blue hues seem muted or that colors appear less vivid.
- Reversible color-perception changes after lens replacement illustrate the optical contribution of the lens.



Nuclear cataract and refraction

- Nuclear sclerosis can change the refractive index of the crystalline lens.
- A myopic shift may temporarily improve near reading in some older patients despite a worsening cataract.
- A refractive improvement is therefore not proof that the lens opacity is regressing.

Structural change

Increasing nuclear sclerosis

Optical change

Altered refractive index

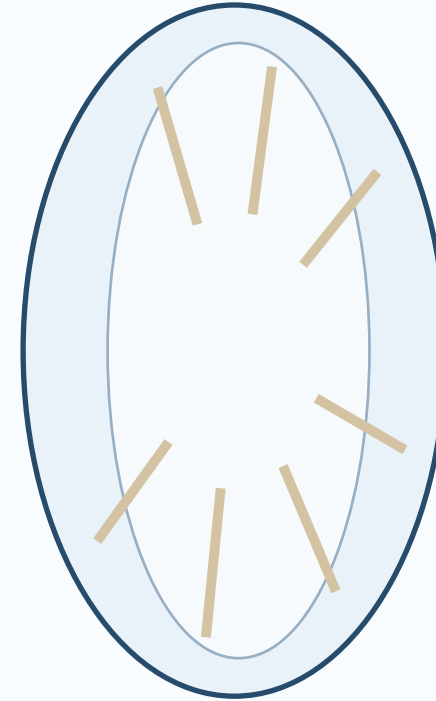
Clinical clue

Unexpected change in spectacle prescription

Cortical cataract: Where it begins

- The cortex occupies the lens periphery around the nucleus.
- Cortical lens material may undergo liquefaction as one mechanism of opacity.
- Cortical opacities may remain peripheral or extend toward the visual axis.

Schematic · lens section



Anterior

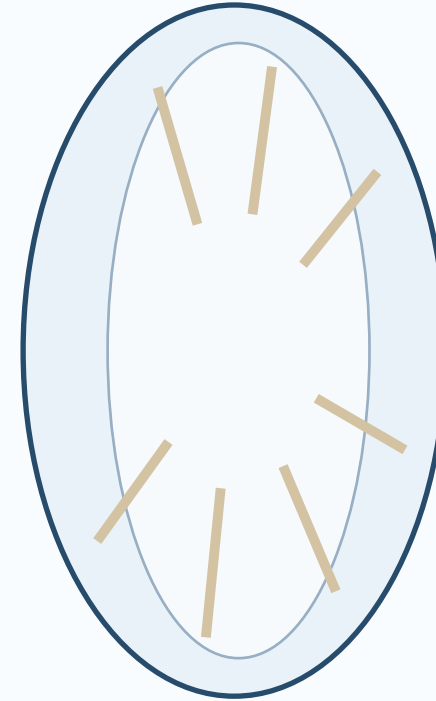
Posterior

Peripheral cortical compartment can become opaque.

Spoke-like cortical opacities

- Cortical cataracts often show radiating or wedge-shaped lens opacities.
- The distribution can produce light scatter, especially under visually demanding lighting conditions.
- Anatomical inspection by slit lamp differentiates cortical spokes from central nuclear discoloration.

Schematic · lens section



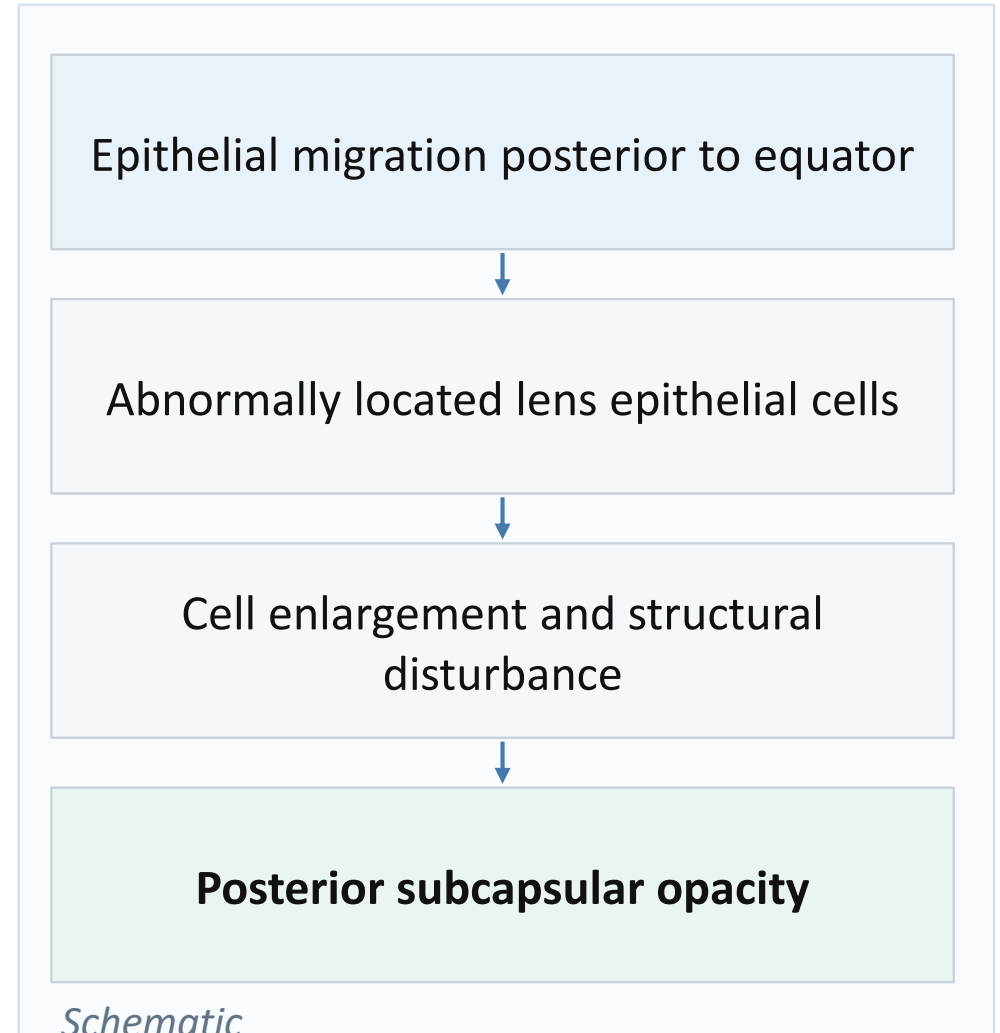
Anterior

Posterior

Radial marks are schematic cortical opacities.

Posterior subcapsular cataract: Pathogenesis

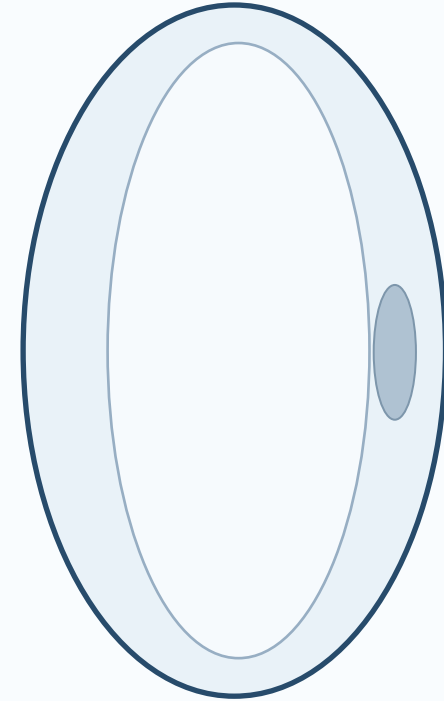
- Lens epithelial cells may migrate behind the equator toward the posterior pole.
- These abnormally positioned cells enlarge and contribute to posterior subcapsular opacity.
- The process differs from age-related nuclear sclerosis and from cortical liquefaction.



Posterior subcapsular cataract: Morphology

- The opacity lies immediately anterior to the posterior lens capsule.
- It can be visually significant when centrally located near the optical axis.
- The affected area is not the cornea and is not an opacified implanted intraocular lens.

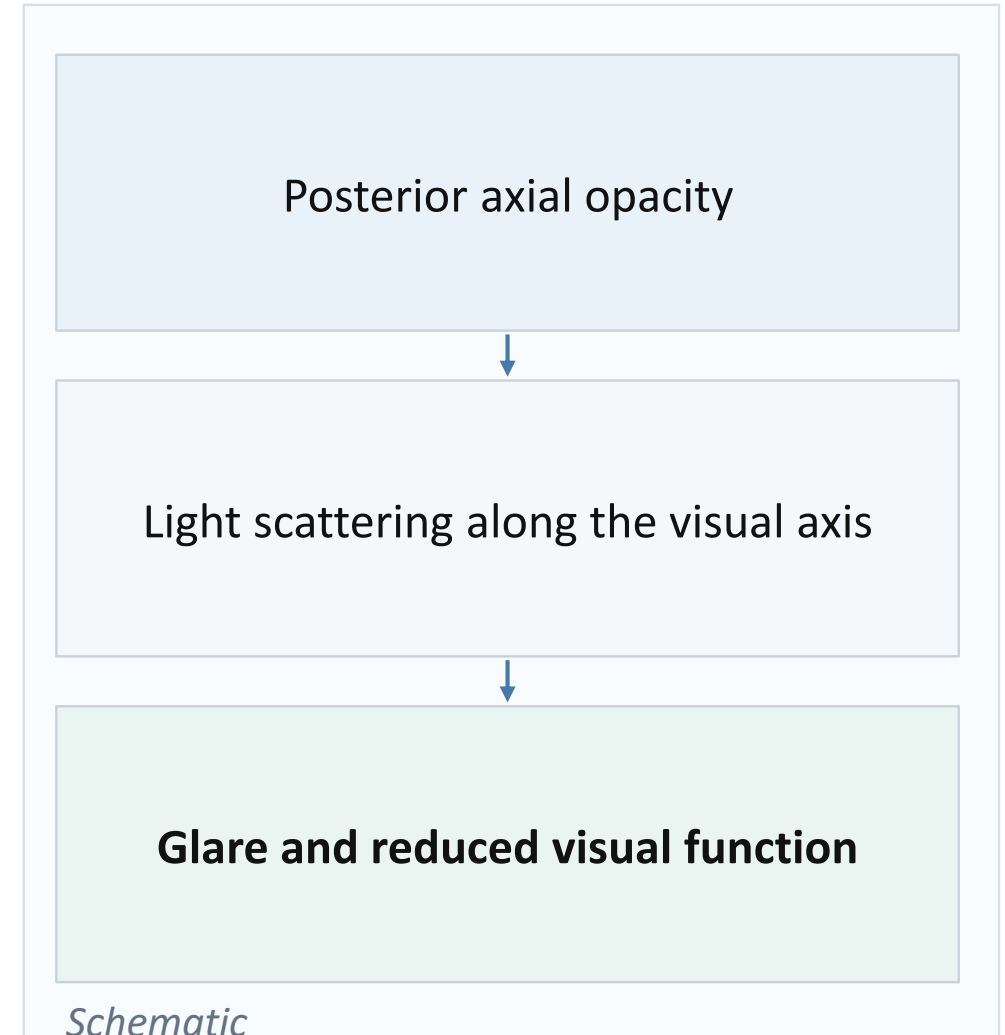
Schematic · lens section



Small posterior axial opacity can impair vision.

Why a small posterior opacity matters

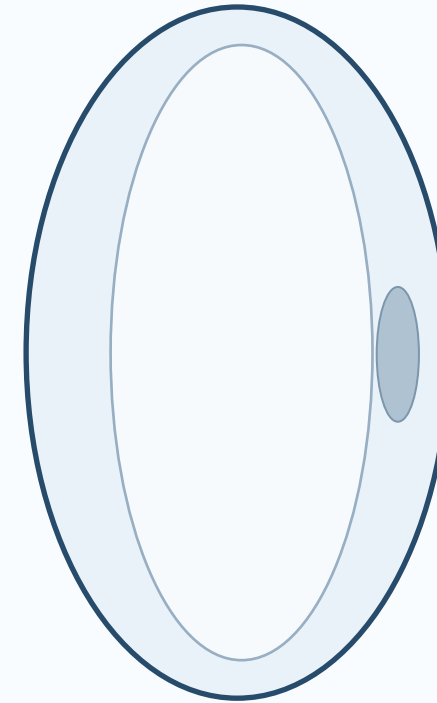
- A posterior subcapsular opacity can lie in the path used by most image-forming light.
- Glare and loss of clarity may be striking despite an opacity that looks limited in extent.
- Morphological size alone is an inadequate surrogate for functional impact.



Posterior subcapsular clinical pattern

- Posterior subcapsular cataract can cause disproportionate visual difficulty in bright conditions.
- Near visual tasks and glare may be especially affected when the opacity is axial.
- The symptom pattern is suggestive, but lens examination remains necessary for classification.

Schematic · lens section



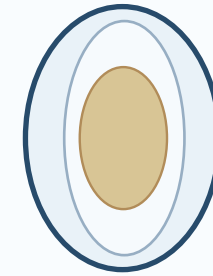
Anterior

Posterior

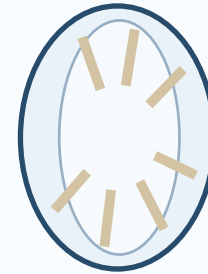
Axial posterior opacity · illustrative schematic

Three major acquired morphologic patterns

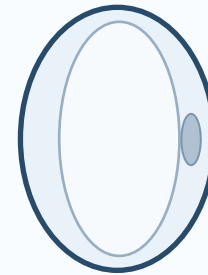
- Nuclear: Central opacification, sclerosis, and often yellow–brown pigmentation.
- Cortical: Peripheral cortical change, including liquefaction and spoke-like opacities.
- Posterior subcapsular: Opacity linked to abnormal epithelial migration and enlargement.



Nuclear



Cortical



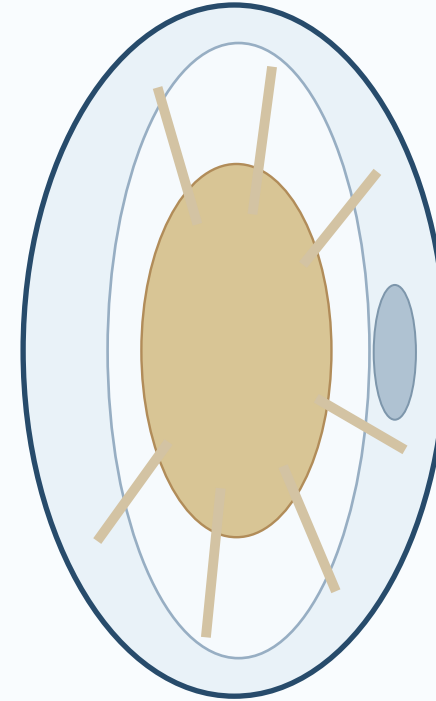
Posterior subcapsular

Schematic · not a clinical specimen

Mixed cataract morphology is possible

- Nuclear, cortical, and posterior subcapsular changes are not mutually exclusive.
- A single lens may show more than one morphological component at examination.
- Describe each observed compartment rather than forcing a mixed opacity into one exclusive subtype.

Schematic · lens section



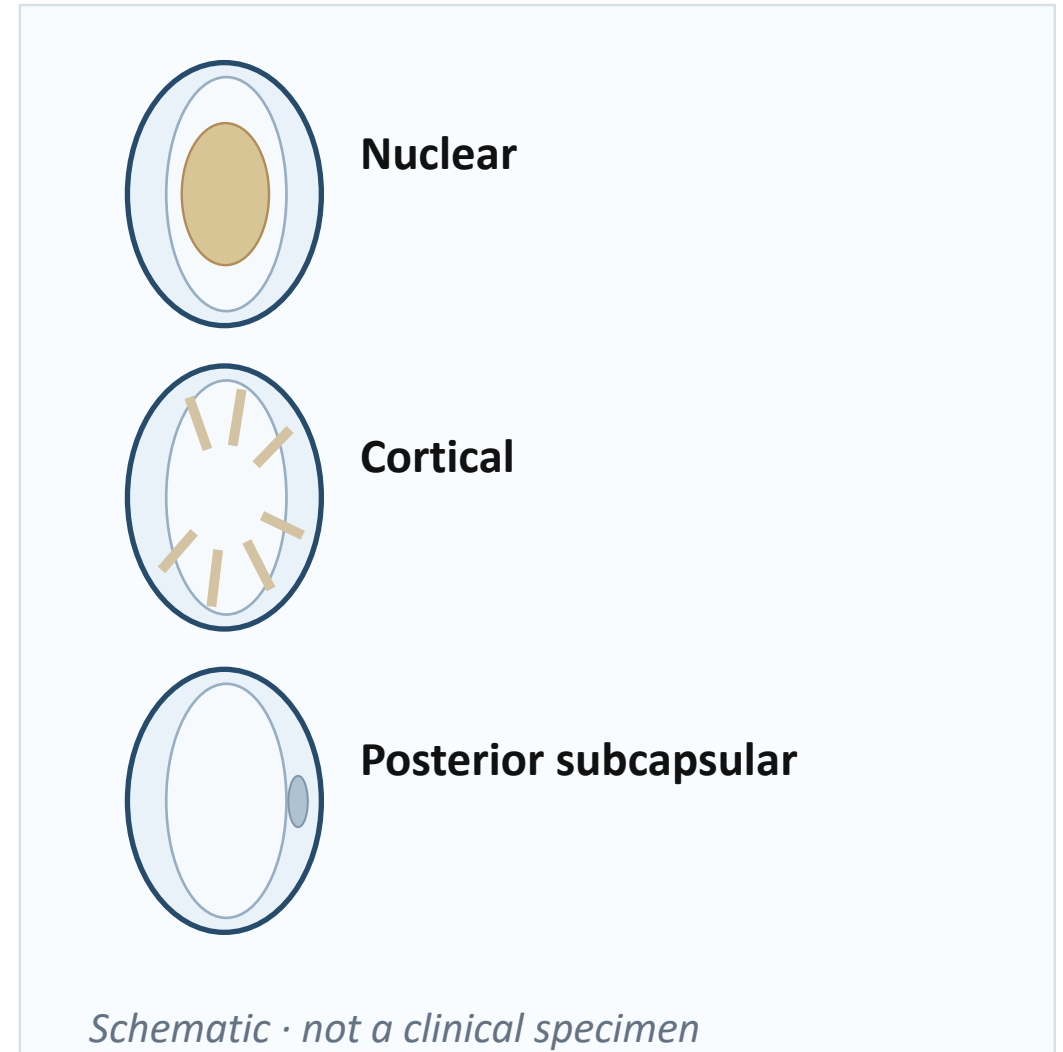
Anterior

Posterior

Combined nuclear, cortical, and posterior opacity

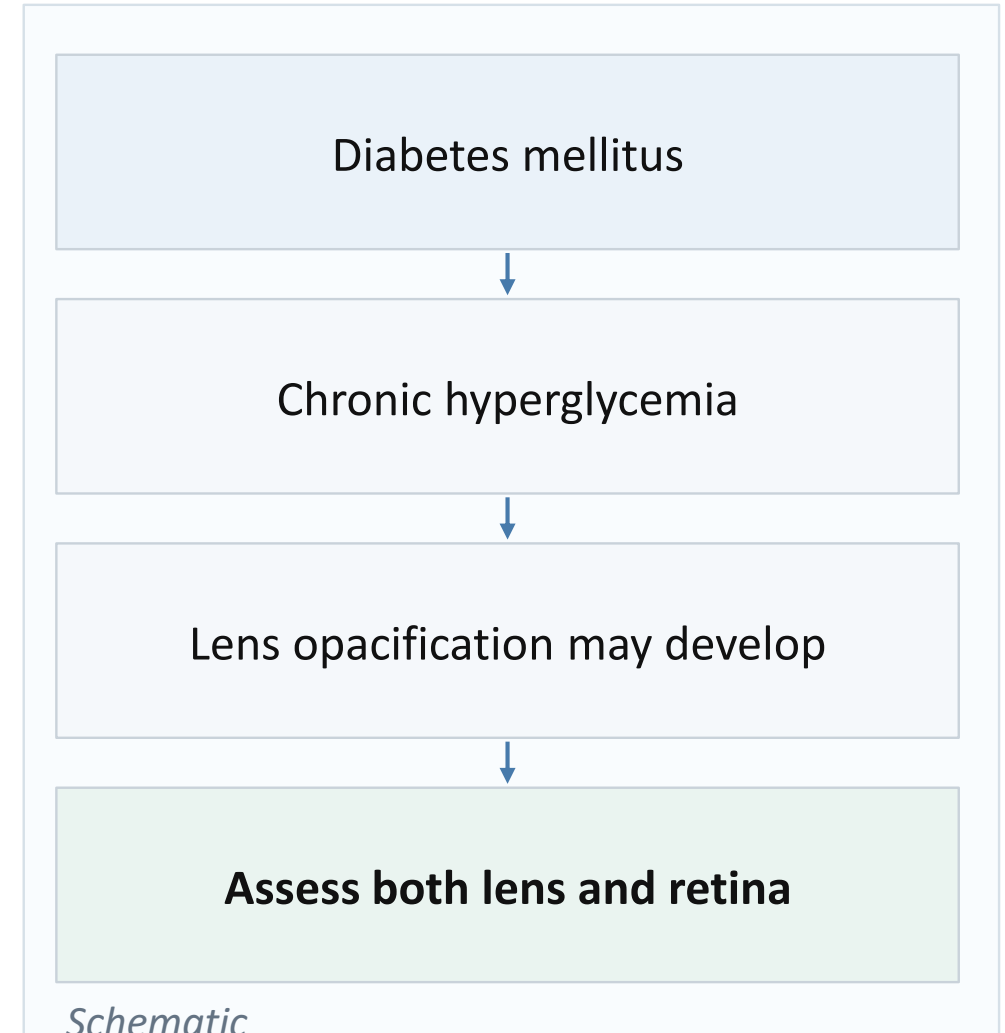
Clinical exercise: Localize the opacity

- A central brown lens nucleus suggests nuclear sclerosis.
- Radial peripheral opacities favor a cortical component.
- A focal plaque near the posterior optical axis suggests a posterior subcapsular component.



Diabetes mellitus and acquired cataract

- Diabetes as a systemic disorder associated with lens opacity.
- Hyperglycemia can contribute to acquired opacification of the lens.
- The same patient may also have retinal disease; Blurred vision should not automatically be attributed only to cataract.



Diabetic visual loss: Lens versus retina

- Lens disease degrades optical transmission before light reaches the retina.
- Diabetic retinopathy is a retinal vascular disorder, anatomically distinct from cataract.
- Coexisting abnormalities can limit expected visual recovery after surgery.

Lens

Opacity compromises the image entering the eye.

Retina

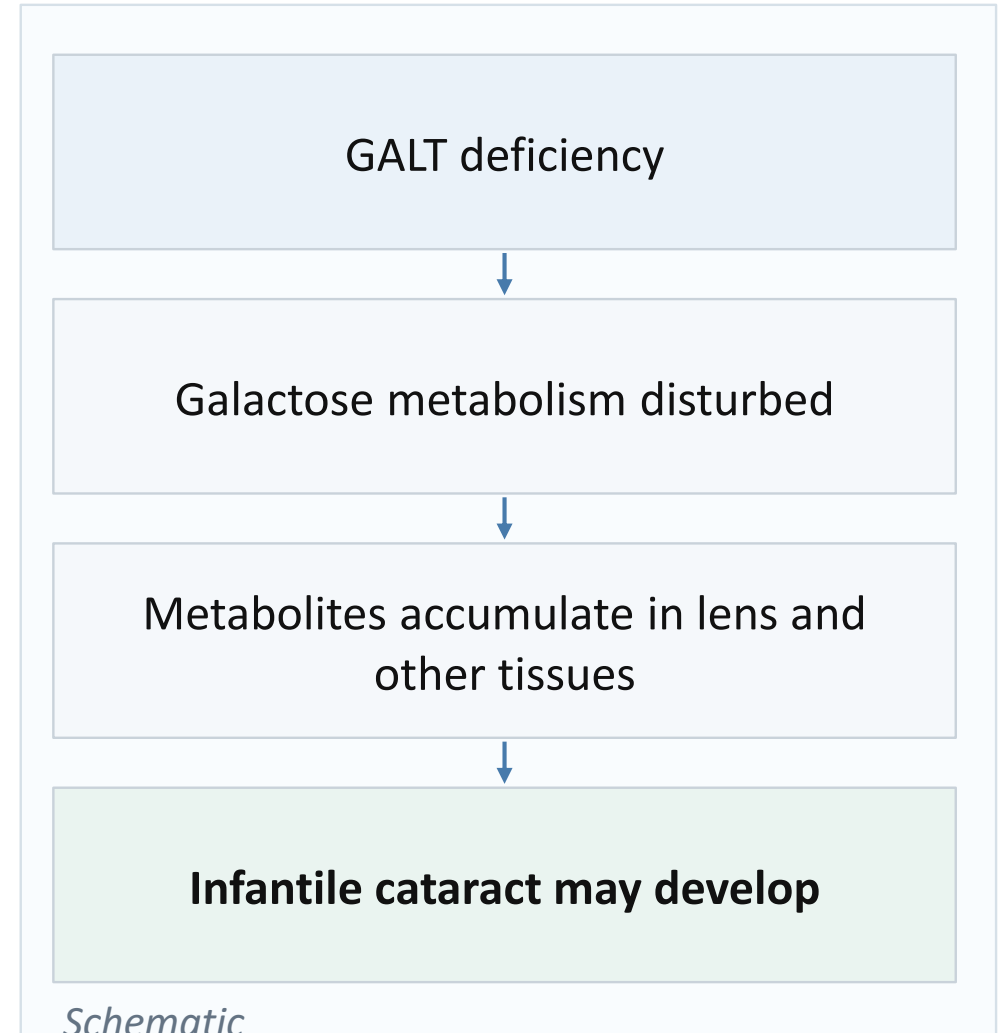
Vascular retinal pathology compromises neural reception.

Clinical synthesis

Evaluate both before predicting visual recovery.

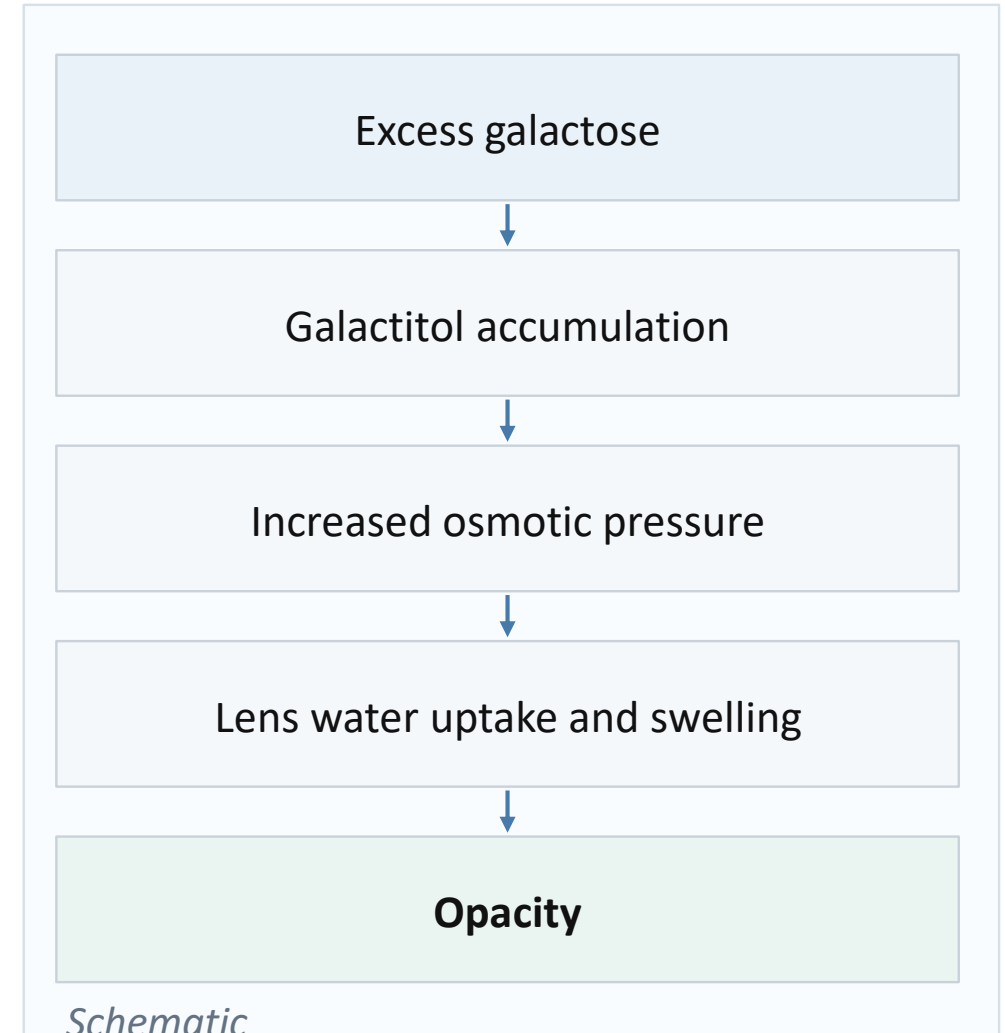
Galactosemia: Metabolic context

- Classic galactosemia may result from deficient galactose-1-phosphate uridylyltransferase (GALT).
- Galactose-1-phosphate and metabolic derivatives accumulate in multiple tissues, including the lens.
- Cataract may be part of a multisystem infant presentation, not an isolated eye problem.



Galactitol and osmotic lens injury

- Alternative metabolism of excess galactose generates galactitol, a polyol.
- Galactitol increases osmotic pressure in lens tissue, promoting water entry and swelling.
- The resulting structural and optical disruption provides a mechanism for congenital/early cataract.



An infant with cataract: Systemic clues

- In galactosemia, an infant may develop vomiting, jaundice, hepatomegaly, and feeding difficulties.
- Early cataract associated with these findings is a marker of possible metabolic disease.
- Eye findings should trigger consideration of systemic metabolic evaluation rather than isolated ophthalmic treatment.

What unites the lens and liver findings?

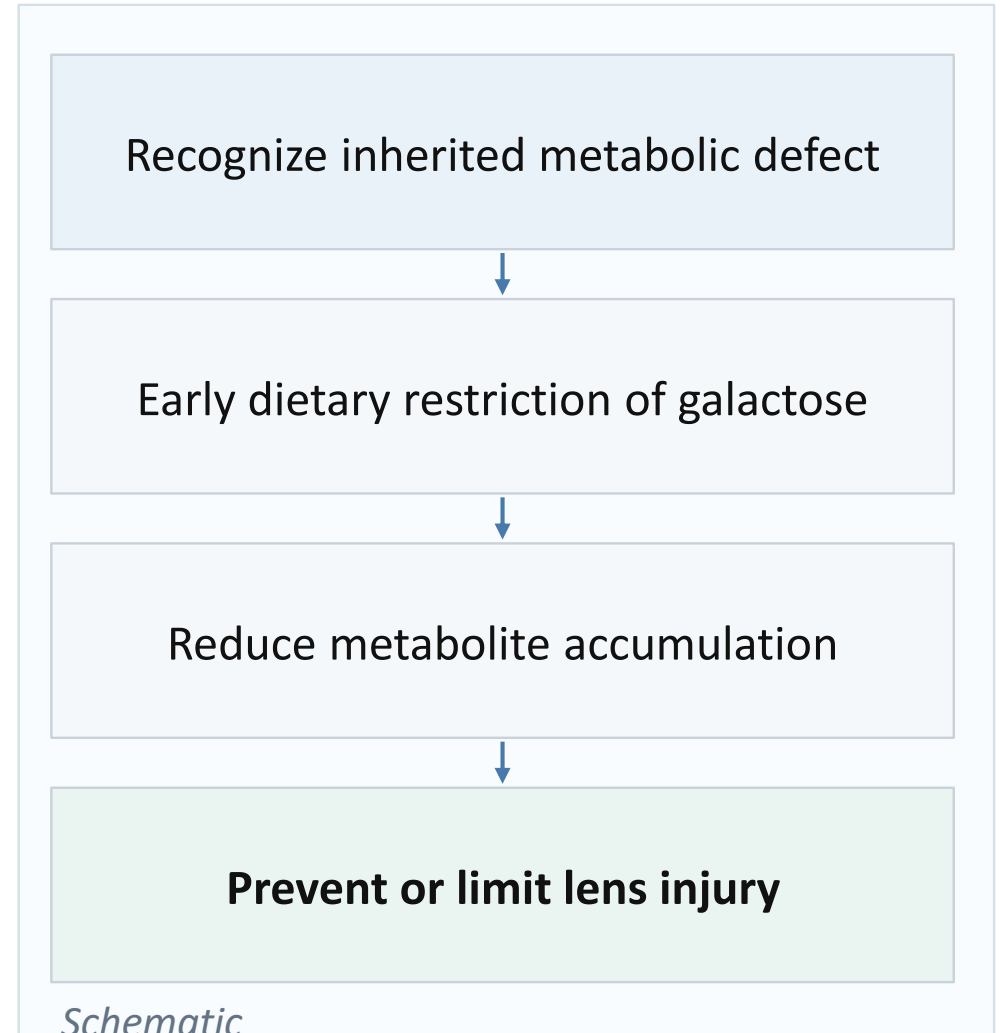
Early-life lens opacity

Milk exposure and feeding symptoms

Jaundice or hepatomegaly

Galactosemia: Prevention matters

- Prompt dietary removal of galactose can prevent or reduce several clinical complications.
- Early intervention can prevent cataracts and liver damage in classic galactosemia.
- Once an opacity is established, evaluate its visual consequences separately from control of the metabolic disorder.



Corticosteroids as an acquired exposure

- Corticosteroids are explicitly identified by Robbins as a major drug association.
- A medicine history is relevant in patients developing an acquired cataract earlier than expected.
- Drug exposure is a risk association, not sufficient alone to identify the morphological subtype.

History

Systemic or ocular corticosteroid exposure

Examination

Document lens compartment and severity

Interpretation

Integrate age and other comorbid factors

Radiation-associated lens opacity

- Radiation is a recognized acquired cause of cataract.
- Exposure history can include therapeutic radiation and prolonged ultraviolet exposure.
- Anatomical assessment remains necessary because exposure history cannot substitute for a lens examination.

Recognize exposure

Document type and relevant history

Identify pathology

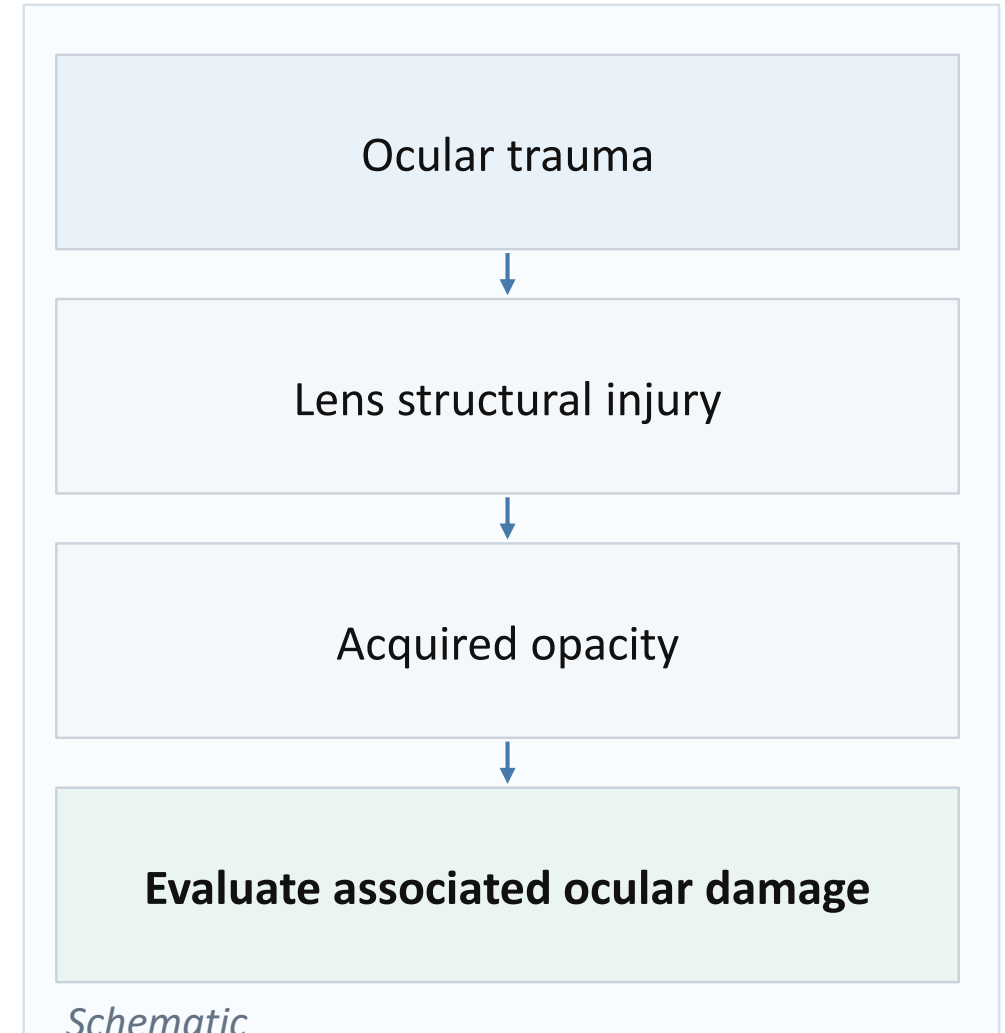
Locate opacity within the lens

Assess function

Correlate findings with visual symptoms

Traumatic cataract

- Direct ocular injury can damage the crystalline lens and produce cataract.
- The opacity may appear after an interval rather than necessarily at the time of injury.
- Examination must also seek associated injury to other ocular structures.



Systemic associations beyond diabetes

- Robbins also lists Wilson disease and atopic dermatitis among systemic associations.
- Atypical age of onset or a characteristic medical history broadens the differential beyond senescence.
- Specific mechanism and morphology should not be assumed solely from the diagnostic label of the systemic illness.

Wilson disease

Systemic condition listed among cataract associations.

Atopic dermatitis

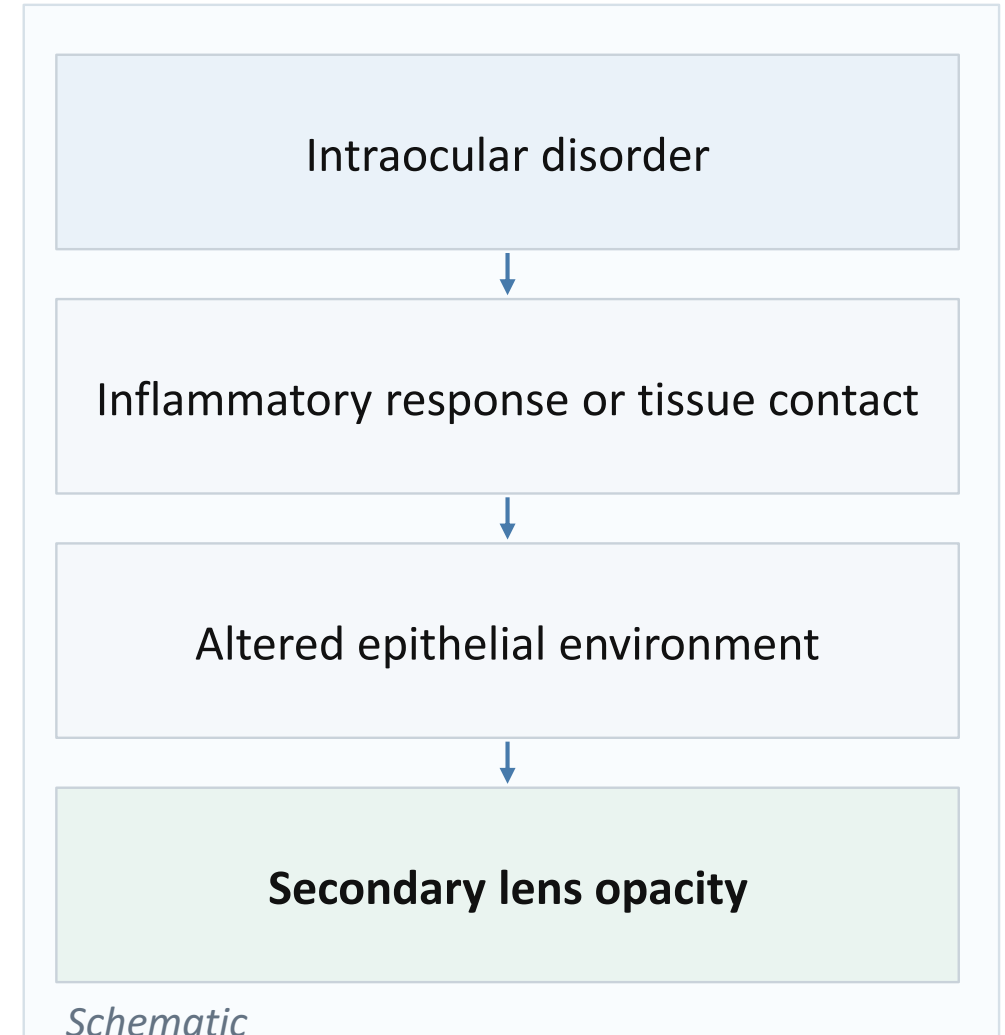
Atopic disease is another listed association.

Clinical safeguard

Confirm actual lens morphology before attributing cause.

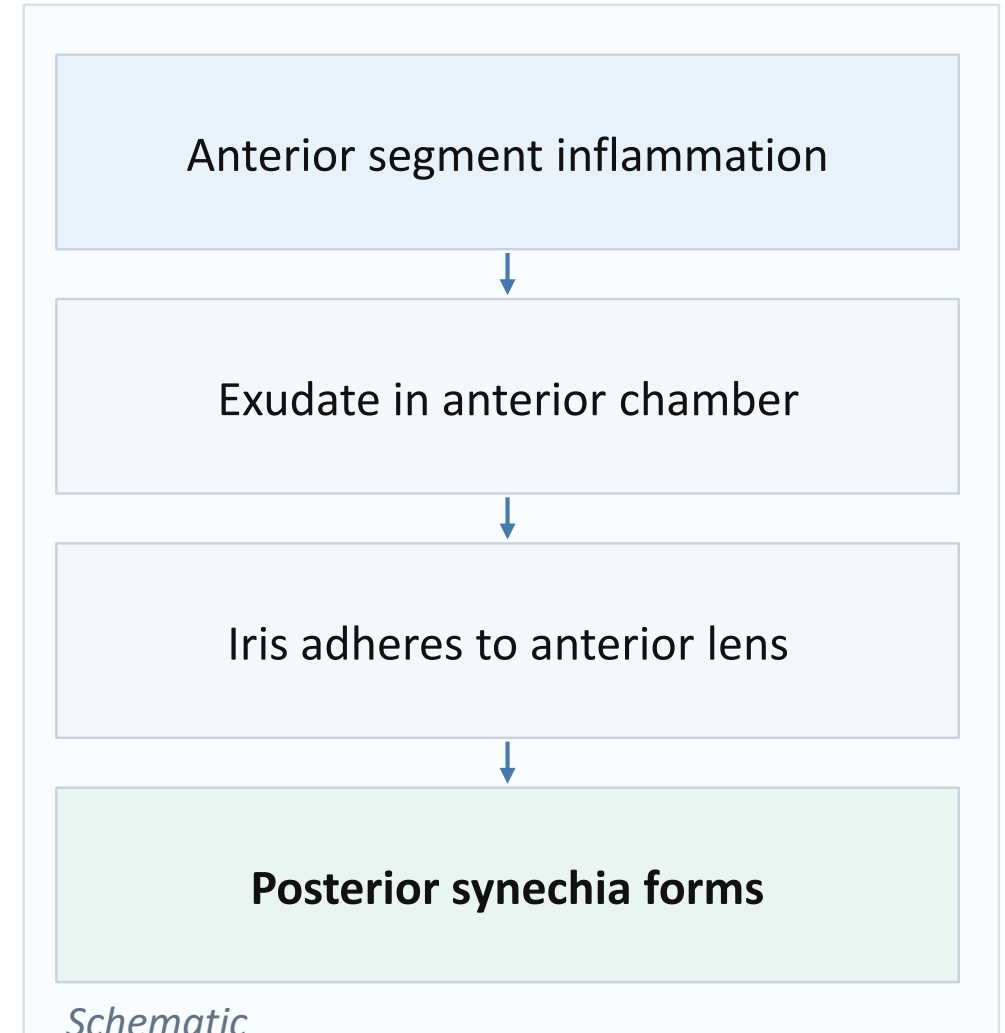
Intraocular disorders can cause cataract

- Robbins groups many intraocular disorders among acquired cataract associations.
- Inflammation is an important example because it can alter the iris–lens relationship.
- The resulting lens pathology may be anterior subcapsular rather than nuclear or posterior subcapsular.



Inflammation and posterior synechiae

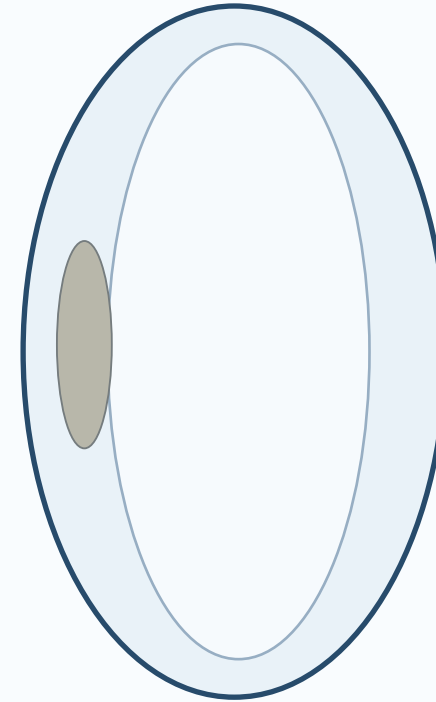
- Inflammatory exudate can promote adhesions between iris and anterior lens surface.
- This iris–lens adhesion is termed a posterior synechia.
- Sustained apposition can disturb access of the anterior lens epithelium to aqueous humor.



Anterior subcapsular cataract from inflammation

- Prolonged posterior synechiae may deprive anterior lens epithelium of its normal aqueous interface.
- The epithelial cells can undergo fibrous metaplasia.
- This produces an anterior subcapsular cataract, an anatomically distinct opacity.

Schematic · lens section



Anterior

Posterior

Anterior epithelial fibrous metaplasia after
synechiae

Do not confuse anterior and posterior processes

- Anterior subcapsular cataract: Associated here with synechiae and fibrous epithelial metaplasia.
- Posterior subcapsular cataract: Associated with epithelial migration behind the equator and enlargement.
- The shared word “subcapsular” does not imply a common pathogenesis.

Anterior subcapsular

Anterior lens epithelial metaplasia.

Posterior subcapsular

Posterior aberrant epithelial migration.

Distinction

Different sides of the lens; Different mechanisms.

Where different cataract causes converge

- Aging alters nuclear properties and pigmentation.
- Metabolic disease can cause lens hydration and opacity; Inflammation can change epithelial differentiation.
- Despite diverse mechanisms, all pathways degrade transparency within the same encapsulated organ.

Nuclear

Age-related sclerosis and pigment

Metabolic

Galactitol-associated osmotic swelling

Inflammatory

Synechiae-associated fibrous metaplasia

Cataract symptoms: The optical phenotype

- Blurred or cloudy vision may progress slowly and initially go unnoticed.
- Glare, halos, difficulty in dim light, and altered color perception are common reported complaints.
- Symptoms are nonspecific: A complete ocular evaluation remains necessary.

Image quality

Blur or haze

Illumination

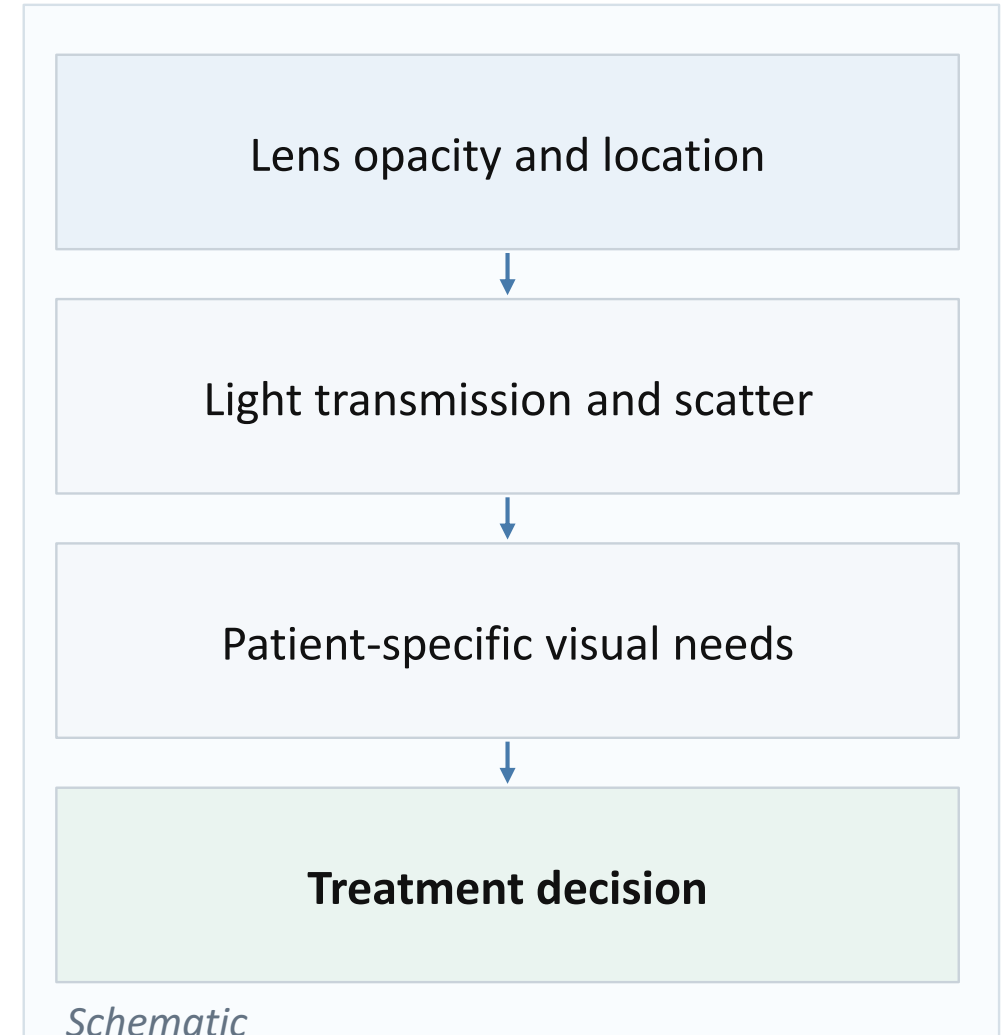
Glare, halos, poor night vision

Color/refractive change

Faded colors or changing spectacle need

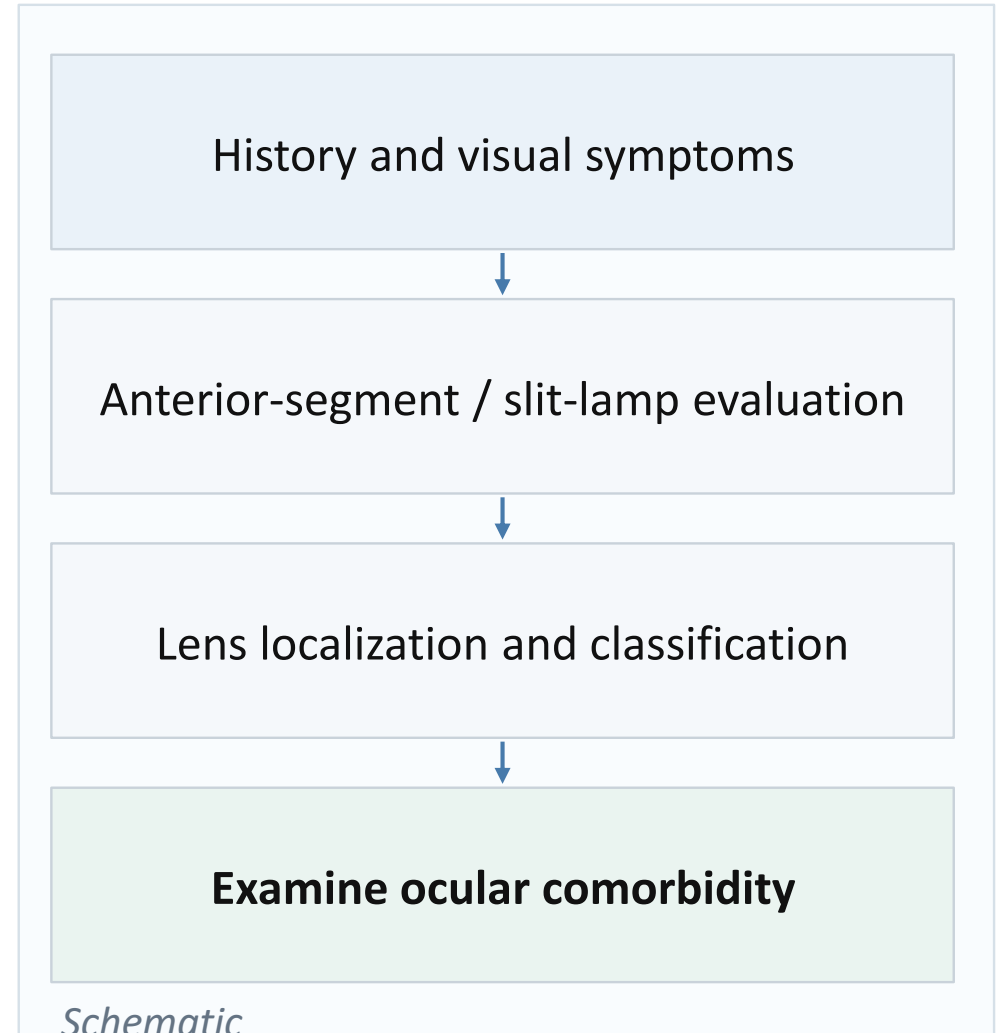
An opacity is not the same as disability

- Anatomical size and centrality influence how much visual function is affected.
- Task demands—reading, driving, and glare exposure—modify the burden of cataract.
- Surgical decisions weigh functional impairment and eye health, not just the presence of opacity.



Clinical examination localizes cataract

- Clinical history establishes onset, laterality, function, and relevant systemic or exposure associations.
- Slit-lamp assessment identifies opacity location and its nuclear, cortical, or subcapsular pattern.
- A dilated examination permits assessment for other ocular causes of reduced vision.



Assessment of visual potential

- The opacity may coexist with retinal, corneal, or optic nerve disease.
- A normal-looking lens does not exclude a retinal mechanism for blurred vision.
- Before counseling about surgery, determine whether nonlenticular disease could limit improvement.

Cornea

Transparency and refractive surface.

Lens

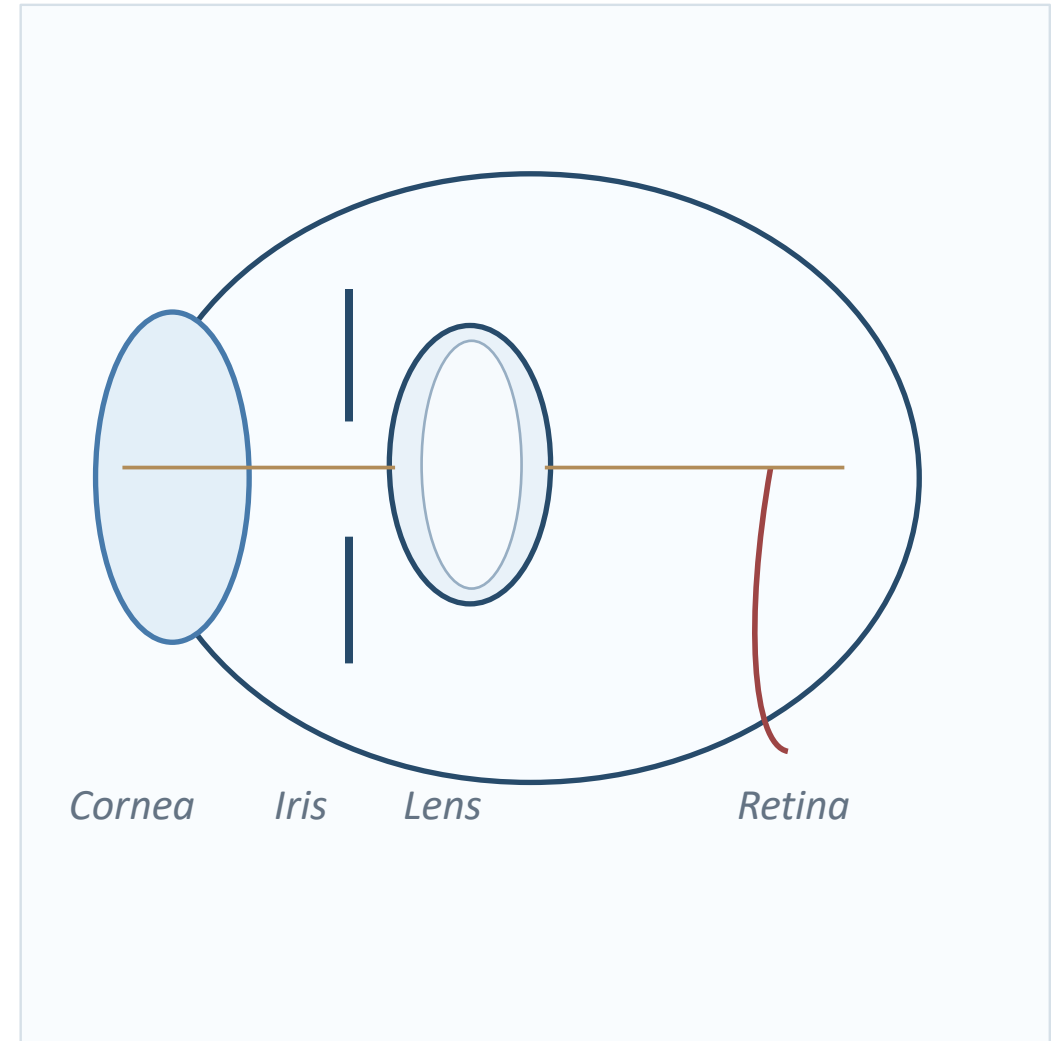
Opacity, position, and severity.

Posterior segment

Retina and optic nerve contribution.

Differential: Cataract versus corneal disease

- Cataract is within the crystalline lens; Corneal edema or scarring is anterior to the aqueous humor.
- The cornea supplies the principal refractive power, and corneal disease may cause major blur independent of lens opacity.
- Examination of both structures prevents incorrect attribution of symptoms to cataract alone.



Pediatric cataract is time-sensitive

- Congenital cataract is an established form of lenticular opacity.
- A visually significant opacity during visual development can contribute to amblyopia.
- Early specialized assessment is essential; A small peripheral cataract may need monitoring rather than immediate operation.

Visual axis

Is the opacity obstructing image formation?

Visual development

Is there risk of deprivation amblyopia?

Management

Pediatric ophthalmology assessment

Case: Infant with lens opacity

- An infant has a visible lens opacity and poor visual fixation.
- First, identify whether the opacity obstructs the visual axis and whether it is unilateral or bilateral.
- Then consider congenital, genetic, metabolic, and prenatal/inflammatory contexts with urgent pediatric ophthalmic review.

What makes pediatric opacity urgent?

Developmental visual deprivation

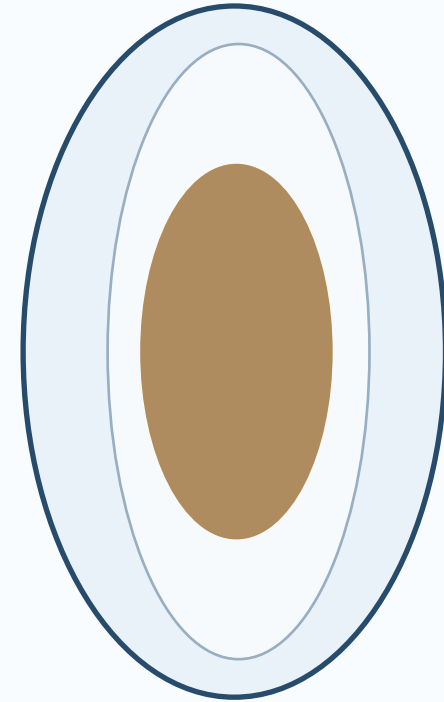
Possible systemic etiology

Need to preserve visual development

Case: Progressive brown nucleus

- An older adult reports gradually less vivid blue colors and changing visual clarity.
- A brownish nuclear lens opacity is seen on examination.
- Nuclear sclerotic cataract explains the combined morphology and color-perception change.

Schematic · lens section



Anterior

Posterior

Hypothetical case · brown nuclear lens opacity

When observation is appropriate

- Early cataracts do not necessarily require immediate surgery.
- Improved lighting, glare reduction, and updated refractive correction may temporarily help.
- Periodic examination documents progression and evaluates competing sources of visual loss.

Mild impairment

Adapt lighting and optical correction

Follow-up

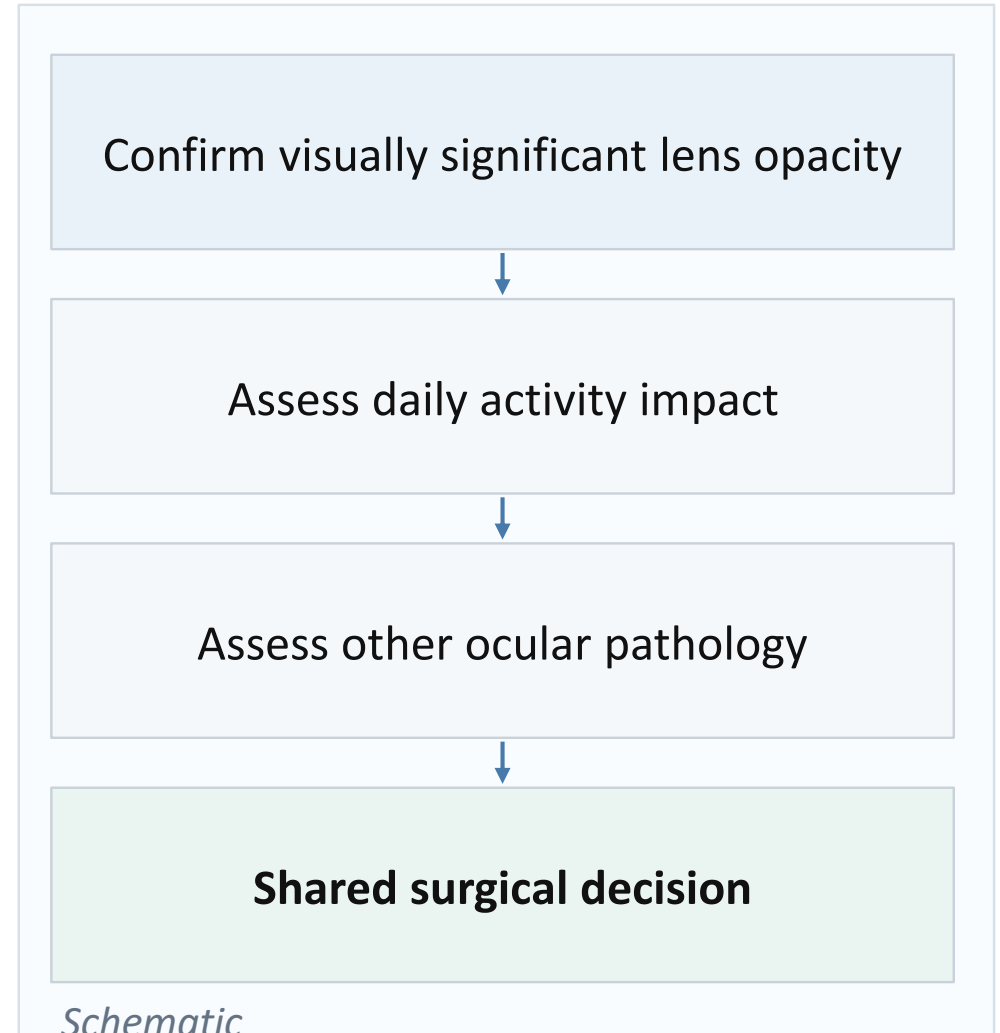
Repeat ophthalmic assessment

Progression

Reconsider surgery as daily function declines

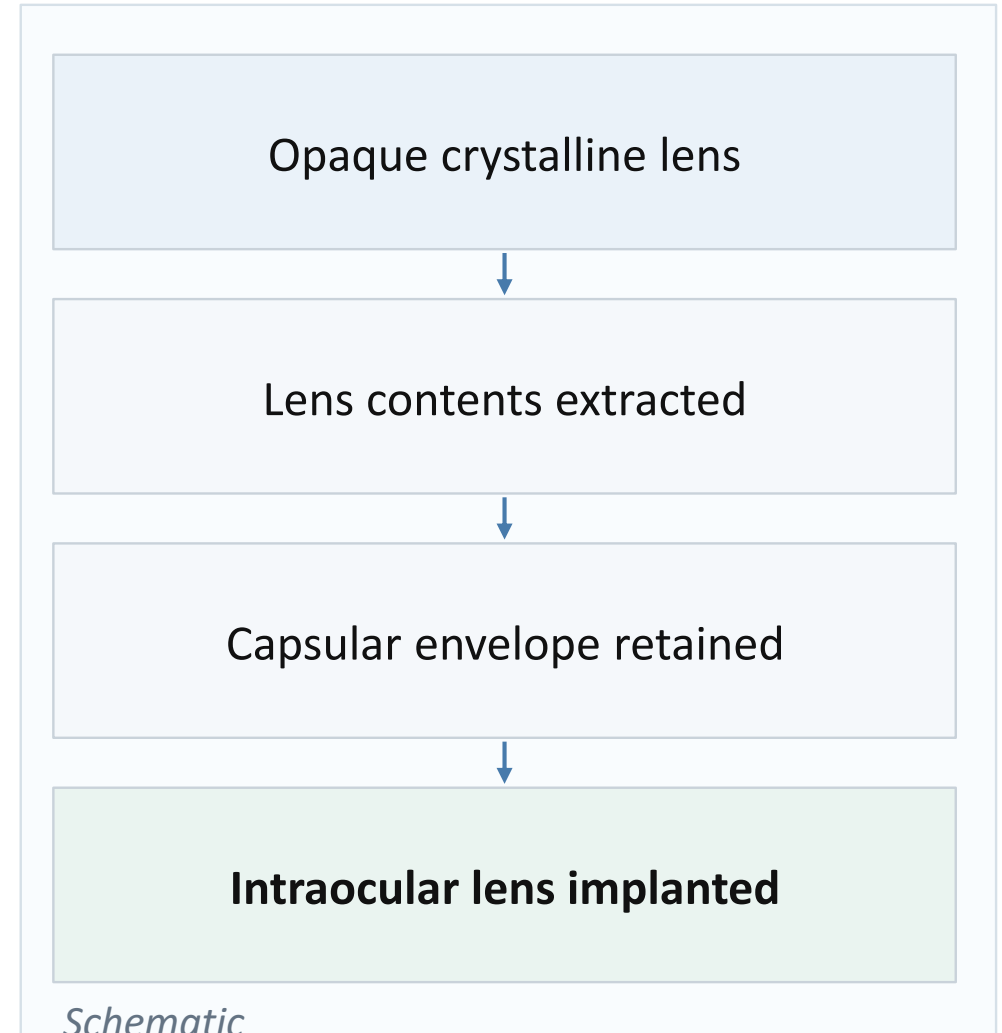
When cataract surgery becomes reasonable

- Surgery is considered when lens opacity interferes with meaningful activities such as reading or driving.
- Removal may also improve visualization and management of other posterior-segment disease.
- The discussion should include expected benefit, comorbid eye disease, and surgical risks.



Surgery: Remove opaque lens contents

- Removal of the opacified lens contents while retaining the capsule.
- The intended result is restoration of a clear optical path, not reversal of nuclear sclerosis within the original lens.
- Capsule preservation provides support for a prosthetic intraocular lens.



The intraocular lens replaces the optical lens

- A prosthetic intraocular lens (IOL) typically substitutes for the extracted crystalline lens contents.
- The IOL restores essential optical power while the natural lens tissue is removed.
- Successful optical replacement does not remove unrelated corneal or retinal disease.

Before

Clouded crystalline lens scatters light.

Procedure

Opaque lens material is extracted.

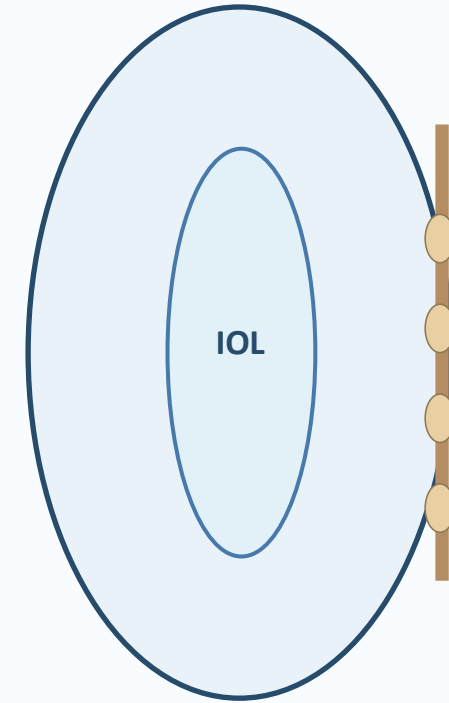
After

Transparent intraocular implant supplies focus.

The retained posterior capsule has clinical importance

- Retaining the capsule facilitates typical IOL placement within the capsular bag.
- Capsular clarity must be maintained for an unobstructed optical axis.
- The retained capsule can later become opaque—a postoperative cause of recurrent blur.

Schematic · lens section



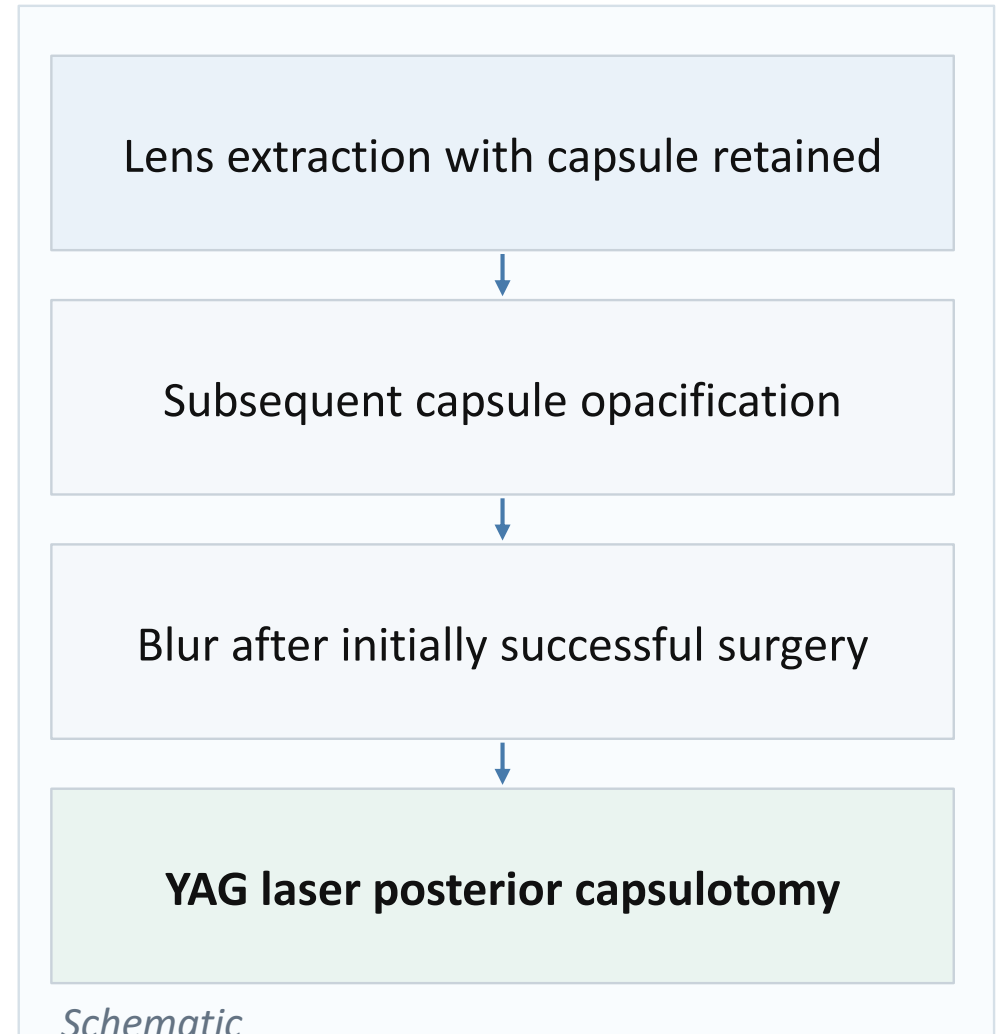
Anterior

Posterior

Schematic · secondary posterior capsule
opacification

Posterior capsule opacification (PCO)

- PCO occurs after cataract extraction when residual capsular region becomes cloudy.
- It is often called a 'secondary cataract', but it is not a new cataract in the removed natural lens.
- A laser posterior capsulotomy can restore clarity by making an opening in the opaque capsule.



Recurrent blur after surgery: Differential

- Consider posterior capsule opacification when vision becomes cloudy again after cataract surgery.
- Corneal endothelial dysfunction and retinal disease are alternative or coexisting explanations.
- An examination must distinguish the structures rather than labeling every postoperative blur 'cataract recurrence'.

Capsule

Posterior capsule opacification.

Cornea

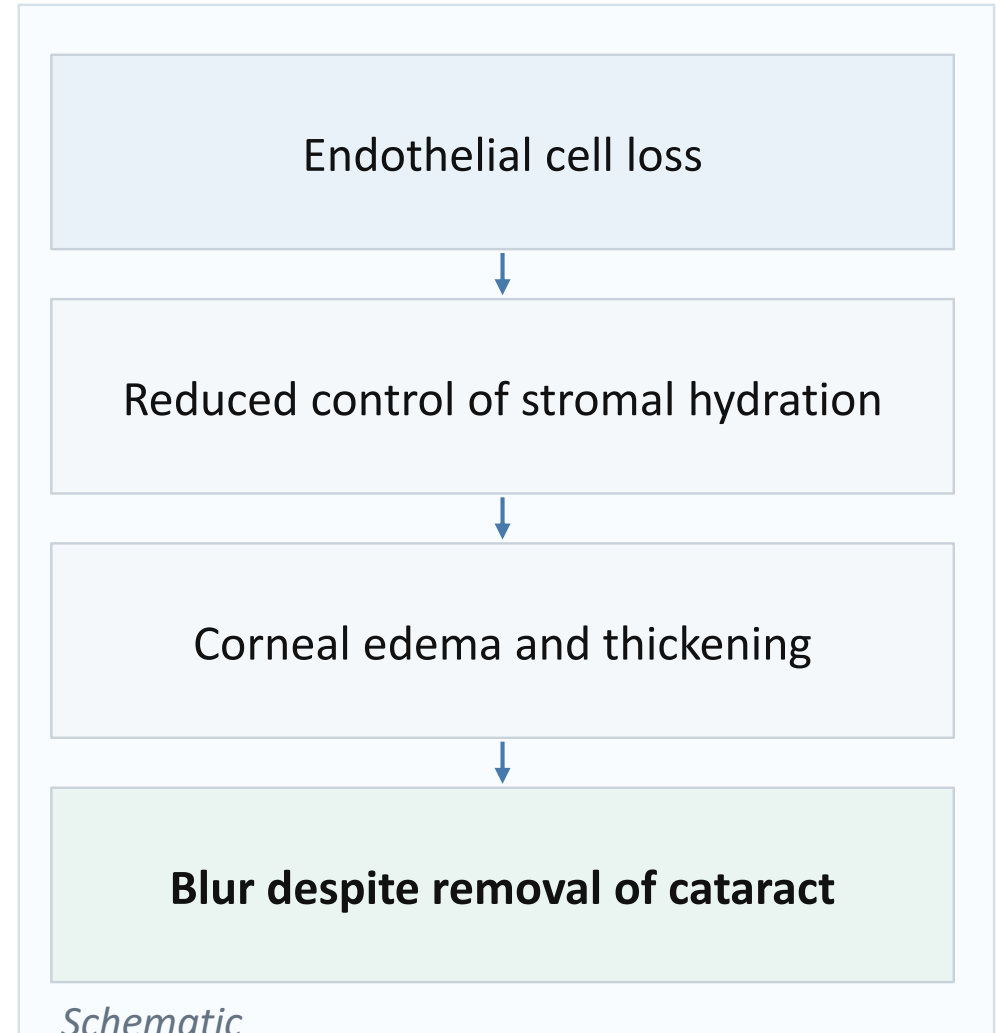
Postoperative edema or pre-existing dystrophy.

Retina

Independent retinal pathology.

Corneal edema after lens surgery

- Corneal endothelial cells may decrease after cataract surgery.
- Endothelial deficiency impairs corneal stromal dehydration, causing edema and blurred vision.
- In susceptible eyes, this can contribute to pseudophakic bullous keratopathy.



Fuchs dystrophy complicates interpretation

- Fuchs endothelial dystrophy compromises corneal clarity through loss of endothelial cells.
- Corneal guttata and subsequent edema belong to corneal, not lenticular, pathology.
- Lens extraction may not eliminate visual loss attributable to an abnormal cornea.

Pre-existing cornea

Endothelial cell depletion may be present.

Lens opacity

Cataract may coexist independently.

Clinical implication

Prognosis depends on both tissues.

Potential surgical complications

- Cataract surgery has benefits but can involve inflammation, infection, pressure abnormalities, or retinal complications.
- New pain, pronounced redness, acute visual deterioration, or new flashes/floaters merit urgent evaluation.
- Complication recognition should remain distinct from expected, gradual postoperative recovery.

Anterior segment

Inflammation, corneal edema, IOP change

Infection

Postoperative endophthalmitis is a serious concern

Posterior segment

Retinal complications, new flashes or floaters

Case: Postoperative visual clouding

- A patient initially sees better after cataract surgery but develops gradually cloudy vision later.
- Posterior capsule opacification is a plausible diagnosis, but slit-lamp localization is necessary.
- Check the cornea, IOL/capsular region, and retina before attributing the decline to 'recurrent cataract'.

Which structure is now opaque?

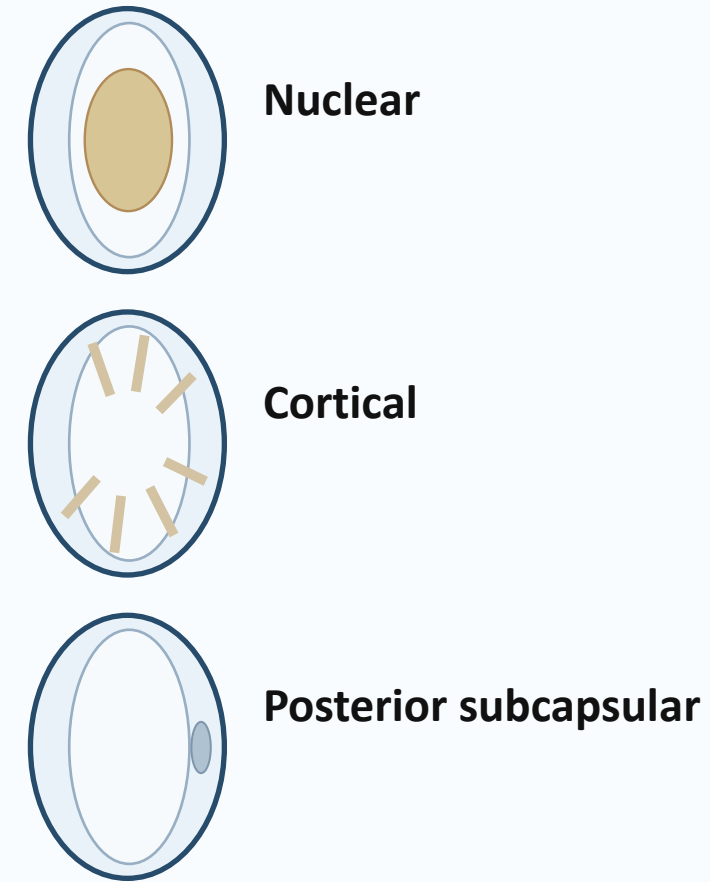
Posterior capsule

Corneal stroma

Retina or other pathology

Morphologic differential at a glance

- Nuclear sclerosis involves the central lens nucleus and may pigment it brown.
- Cortical cataract affects peripheral lens tissue; Posterior subcapsular cataract lies immediately anterior to the back capsule.
- Anterior subcapsular cataract may arise from epithelial fibrous metaplasia following prolonged posterior synechiae.



Schematic · not a clinical specimen

Mechanism-matching exercise

- Brown nucleus with impaired blue discrimination → nuclear sclerosis and pigment accumulation.
- Galactosemia with early lens swelling → osmotic consequences of galactitol accumulation.
- Inflamed eye with iris–lens adhesions → possible anterior subcapsular fibrous metaplasia.

Nuclear

Pigmentation and sclerosis

Metabolic

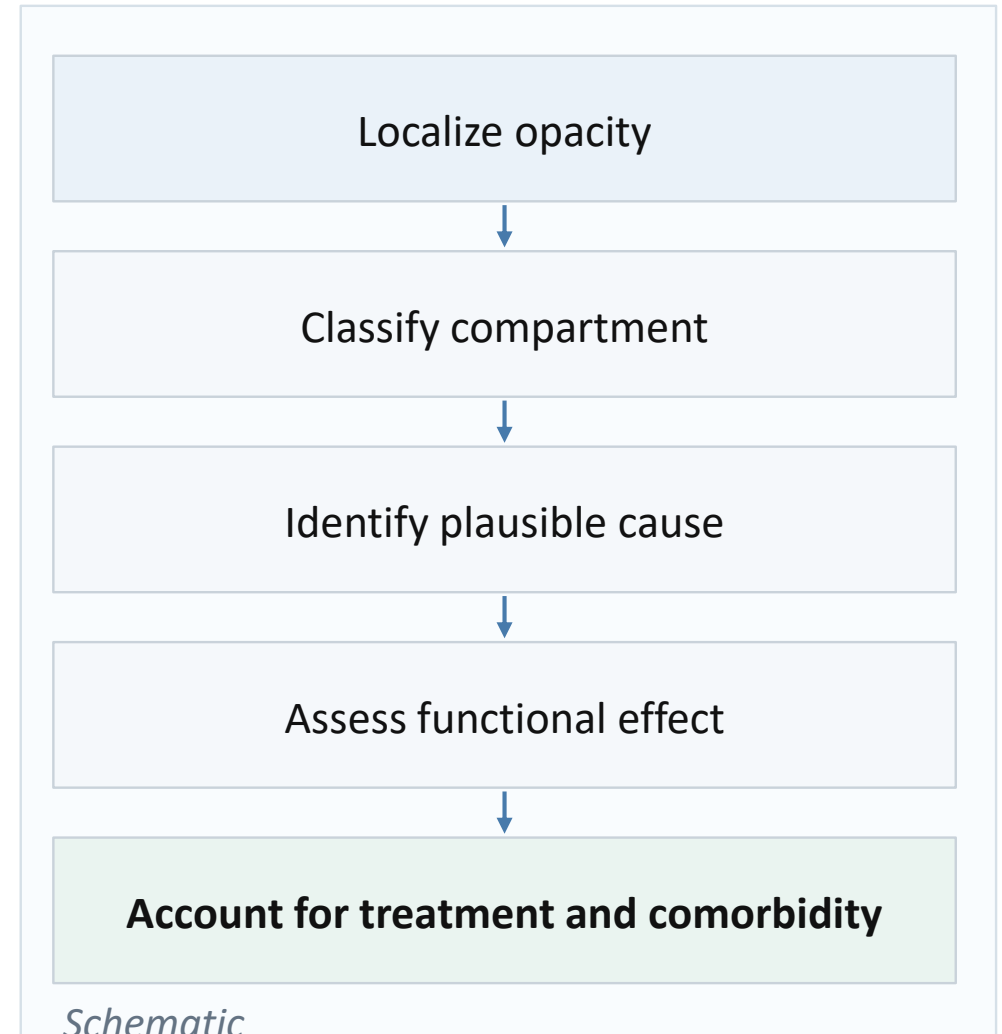
Osmotic lens swelling

Inflammatory

Epithelial fibrous metaplasia

Five principles to retain

- Cataract is lenticular opacity; Localization precedes etiologic attribution.
- Nuclear, cortical, posterior subcapsular, and anterior subcapsular changes have distinct morphological mechanisms.
- Systemic metabolic disease, medications, radiation, trauma, and inflammation contribute to acquired cataract.
- Treat visual disability in its anatomical context: Capsule-sparing extraction with IOL is usual; Ocular comorbidity still matters.



Selected references and source boundaries

Primary textbook

Robbins, Cotran & Kumar. Pathologic Basis of Disease. 11th ed. 2026. Chapter 29, pp. 1193–1195; Chapter 10, p. 424; Chapter 24, p. 1009.

Clinical classification

American Academy of Ophthalmology. Cataract in the Adult Eye, Preferred Practice Pattern (2021); EyeWiki: Cataract.

Clinical assessment

National Eye Institute. Cataracts (updated August 19, 2026); Types of Cataract (2025); Cataract Surgery (2024).