The cornea is transparent, densely innervated, avascular, and the major refractive structure of the eye. A healthy cornea achieves and maintains transparency due to the organization of constituent cells and collagen fibers, as well as its relatively dehydrated state. Anything that alters this organization or deturgescence leads to development of a corneal opacity.1

As the outer and most exposed structure of the globe, the cornea is not only at risk for trauma, but also often receives close attention from clients. As such, a presenting complaint of corneal opacity is common in veterinary practice.

Correct interpretation of corneal changes is critical for diagnosing corneal disease as well as many other ocular and some systemic diseases. Therefore, appropriate diagnostic tests and prompt initiation of optimal therapy are required to maximize the chance of saving vision, producing a comfortable globe and, occasionally, saving the patient’s life.

The following questions should be asked when a patient with a corneal opacity is presented for evaluation.

**QUESTION 1. WHAT IS THE APPEARANCE OF THE OPACITY?**

Causes of corneal opacities, which are often seen in various combinations, are listed in Table 1.2 Each of these pathologic changes is associated with a specific appearance—especially color. However, appropriate diagnostic tests and prompt initiation of optimal therapy are required to maximize the chance of saving vision, producing a comfortable globe and, occasionally, saving the patient’s life.

<table>
<thead>
<tr>
<th>CAUSES OF CORNEAL OPACITY</th>
<th>CORNEAL APPEARANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edema</td>
<td>Blue “cobblestoned” appearance</td>
</tr>
<tr>
<td>Inflammatory cell infiltration</td>
<td>Yellow, green, or tan corneal stromal opacity</td>
</tr>
<tr>
<td>Lipid/mineral deposition</td>
<td>Silvery white, crystalline, sparkly opacities; sometimes coalescing creamy or shiny opacities</td>
</tr>
<tr>
<td>Fibrosis</td>
<td>Grayish white, sometimes feathery or wispy opacity</td>
</tr>
<tr>
<td>Melanosis</td>
<td>Dark brown to black, variable density; often with blood vessels</td>
</tr>
<tr>
<td>Vascularization</td>
<td>Variously perfused blood vessels extending from corneoscleral limbus</td>
</tr>
</tbody>
</table>

**Figure 1.** Focal corneal edema secondary to corneal ulceration in a dog. The pupil has been pharmacologically dilated. Note the loose epithelial edges of the corneal ulcer suggestive of a superficial chronic corneal epithelial defect (SCCED). Resolution was achieved by debridement (using a sterile cotton-tipped applicator) and topically applied antibiotics and atropine. Courtesy University of California–Davis Comparative Ophthalmology Service.
assessment of texture, depth, location, pattern, shape, and outline of the region of opacification is also important as some colors can look similar.

**Edema**
A blue, “cobblestoned” appearance of the cornea—whether focal or diffuse—is indicative of corneal stromal edema, and results from loss of corneal epithelial or endothelial cell function.

**Focal Edema.** Specific causes of focal edema include focal corneal epithelial dysfunction (due to corneal ulceration), or focal endothelial cell damage (due to blunt corneal trauma, lens luxation, or keratic precipitates) ([Figure 1](#), page 105).

**Diffuse Edema.** Diffuse corneal edema ([Figure 2](#)) is more consistent with intraocular disease, such as glaucoma or uveitis, but may also indicate breed-related endothelial dystrophy or age-related endothelial degeneration. These conditions can usually be differentiated by assessing for signs of pain or inflammation: the latter 2 conditions are nonpainful and noninflammatory, whereas glaucoma and uveitis are painful and associated with other signs of inflammation.

Whenever possible, treatment for diffuse corneal edema should always be directed at the underlying disease process, especially since both glaucoma and uveitis are vision-threatening diseases, and some causes of uveitis can even be life-threatening. When no cause is found or the underlying disease is untreatable, symptomatic treatment with hypertonic sodium chloride (NaCl) ophthalmic ointment may be attempted, but it often has little to no effect, may irritate the eye, and requires administration at least 4 to 6 times daily.

**Diffuse Edema in Cats.** Cats are rarely affected with endothelial dystrophy or senile endothelial degeneration. Instead, severe, diffuse corneal edema in cats is typically seen with acute bullous keratopathy ([Figure 3](#)). This condition, which is more common in younger cats, has no recognized predisposing cause and an extremely acute onset that leads to massive stromal edema and, sometimes, corneal rupture. The dysfunction may involve the stroma itself rather than the endothelium or epithelium. Treatment involves emergency surgical support—either conjunctival grafting or placement of a third eyelid flap.

**Inflammatory Cell Infiltration**
A yellow, green, or tan corneal stromal opacity suggests white blood cell (WBC) infiltration, which
is most frequently caused by bacterial infection of the cornea, often *Pseudomonas* or beta-hemolytic *Streptococcus* species (Figure 4). Melting of the corneal stroma (keratomalacia), sometimes with associated stromal loss, is seen in conjunction with WBC infiltration. Keratomalacia is evident as loss of normal corneal curvature and architecture with “oozing” of softened sections of the cornea over the more dependent regions (Figure 4). It occurs as a result of enzymatic breakdown of corneal collagen by collagenases of WBC and bacterial origin, especially *Pseudomonas* species.6

**Therapeutic Approach.** Cytology, aerobic bacterial culture, and sometimes fungal culture are strongly recommended to help guide therapy. Infected corneas require intensive medical therapy, including:

- Frequent (up to Q 2 H) topical application of broad-spectrum bactericidal antibiotics and serum. (Serum contains anticollegenases that reduce keratomalacia.)
- Systemically administered analgesics (nonsteroidal anti-inflammatory drugs and/or opiates)
- Application of an e-collar.

If more than 50% of the corneal stroma is lost, conjunctival graft surgery is often recommended to provide immediate tectonic support and promote healing.2

In some disease processes infiltration of the corneal stroma by WBCs is evident as excretions above the corneal surface. Examples include feline eosinophilic keratitis (FEK; Figure 5) and chronic superficial keratitis (CSK, or “pannus”; Figure 6) in dogs, or neoplastic keratitis (typically lymphoma). In these instances, the cornea typically becomes heavily vascularized due to chronicity of the process.

For the immune-mediated keratitides, it is important to treat any underlying conditions. For example, feline herpesvirus type 1 (FHV-1) is believed to cause FEK in many cats; in dogs, ultraviolet (UV) light exposure is a risk factor for development and progression of CSK. These immune-mediated diseases must be controlled with topical application of steroids and/or calcineurin inhibitors, such as cyclosporine or tacrolimus.7,8

**Keratic Precipitates.** WBCs, typically in association with fibrin, can also form keratic precipitates (KPs)—more discrete clumps located on the inner corneal endothelium that appear as focal tan spots (sometimes likened to mutton fat because of their greasy appearance; Figure 7). Due

*FIGURE 5. Feline eosinophilic keratitis. Note the dense superficial corneal vessels and raised white corneal plaques. Diagnosis is made by cytology, and treatment consists of antiviral and immunomodulatory drugs. Courtesy University of California–Davis Comparative Ophthalmology Service*

*FIGURE 6. Chronic superficial keratitis (CSK) or “pannus” in a German shepherd dog. Note the dense lateral paraxial corneal plaque. This is an immune-mediated condition in which ultraviolet (UV) light exposure is a cofactor. Treatment includes topical immunomodulatory drugs and decreased UV exposure. Courtesy University of California–Davis Comparative Ophthalmology Service*

*FIGURE 7. Keratic precipitates (KPs) in a cat with uveitis. Rubeosis iridis (neovascularization of the iris) is also present. The brown KPs are located on the inner aspect of the corneal endothelium, predominantly ventrally. KPs are a pathognomonic sign of anterior uveitis. Courtesy University of California–Davis Comparative Ophthalmology Service*
to gravity, KPs tend to be deposited most densely on the ventral corneal endothelium, and can be overlooked if the patient’s nose is not directed ventrally, which causes the eye to roll upward. KPs are a pathognomonic sign of uveitis, and a thorough diagnostic workup is usually warranted.9

Lipid/Mineral Deposition
Silvery white, crystalline, sparkly opacities (or sometimes coalescing creamy or shiny opacities) typically located in the anterior stroma, immediately under the corneal epithelium, represent lipid (typically cholesterol) or mineral (typically calcium) deposits.9 These can:2,10
• Occur secondary to chronic keratitis or senile degeneration (also known as corneal or calcareous degeneration or calcific band keratopathy)
• Be a breed-related corneal dystrophy
• Appear secondary to chronic topical corticosteroid therapy (steroid lipid keratopathy) or systemic lipid or possibly mineral imbalances.

Identification of Causes. The most likely of these causes can be identified based on a thorough history and characterization of the lipid/mineral deposition pattern. Lesions secondary to age or chronic keratitis are typically irregular, often unilateral, and accompanied by other signs of keratitis, such as fibrosis, edema, or vascularization.

Inherited dystrophic lesions are typically central or paracentral, circular or elliptical, and bilaterally symmetrical (Figure 8). They are common in many dog breeds, including Siberian huskies and beagles, but are very rarely seen in cats.

Steroid keratopathy can appear very similar to corneal lipid dystrophy but is associated with chronic topical steroid use rather than breed-associated, and appears unilaterally unless corticosteroid use has been bilateral.

Therapeutic Approach. Corneal dystrophy and steroid lipid keratopathy are slowly progressive or static, have minimal effect on vision, and require no therapy (although some recommend replacement of topically applied corticosteroids with topical nonsteroidal anti-inflammatory agents). By contrast, corneal degeneration can cause recurrent corneal ulceration and, in severe cases, corneal rupture, if areas of mineral “chip” off the cornea or reduce corneal epithelial adhesion. If extensive or progressive corneal mineral deposition is present, topical chelation therapy and debridement, or even keratectomy, may be required.2

Fibrosis
If the cornea has a grayish white, sometimes feathery or wispy opacity, it is most likely fibrosed (Figure 9). Hypoperfused (or “ghost”) corneal blood vessels may be seen in association with resolving or inactive corneal fibrosis, but well-perfused vessels indicate more active keratitis.

In most cases, corneal scarring is permanent, but can decrease over time if the underlying cause of corneal damage is removed, especially in younger animals. Corneal scars do not retain fluorescein stain and require no further treatment.9 However, if extensive scarring causes vision loss, corneal transplantation may be considered.

QUESTION 2. WHERE IS THE OPACITY LOCATED?
As seen with the examples provided in Question 1, location, depth, and extent of corneal opacity can be
diagnostically critical (Table 2).

Accurate judgment of lesion depth within the cornea requires use of magnification and a slit lamp; however, corneal vessels can also be useful clinical guides:

• **Superficial corneal blood vessels** arise from the conjunctiva at the limbus and are fine, branching dichotomously to form “tree-shaped” patterns on the cornea, and can usually be seen crossing the limbus (Figure 10). These vessels typically indicate superficial ocular surface disease.

• **Vessels that arise from under or within the scleral shelf** are located deeper in the cornea, where they form a more “hedge-shaped” pattern (Figure 11). They are characteristic of deeper, more serious, vision-threatening diseases, such as deep keratitis, uveitis, and glaucoma.9

### Table 2. Location & Cause of Corneal Opacities

<table>
<thead>
<tr>
<th>CORNEAL OPACITY LOCATION</th>
<th>LIKELY CAUSE &amp; RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paraxial corneal ulcer</td>
<td>Adnexal region closest to corneal ulcer should be investigated for abnormalities, such as distichia, ectopic cilia, or foreign bodies (often associated with intense blepharospasm), or entropion/ectropion</td>
</tr>
<tr>
<td>Lateral perilimbal to paraxial corneal edema of both eyes</td>
<td>Typical of age-related corneal endothelial degeneration; edema progresses medially until it covers entire cornea causing vision impairment2</td>
</tr>
<tr>
<td>Circumferential perilimbal corneal edema, cellular infiltrates, and/or vessels</td>
<td>Can indicate diffuse episcleritis or lymphoma²</td>
</tr>
<tr>
<td>Corneal ulcer and focal edema near 12 o’clock position on dorsal paraxial cornea</td>
<td>In a young dog, warrants thorough examination for ectopic cilia (certain breeds, such as Shih Tzu, are predisposed)</td>
</tr>
<tr>
<td>Diffuse corneal edema</td>
<td>Typically indicates intraocular disease (Figure 2)</td>
</tr>
<tr>
<td>Diffuse superficial corneal vessels</td>
<td>Suggests chronic, diffuse superficial irritation, such as keratoconjunctivitis sicca (KCS or dry eye); when associated with mucoid to mucopurulent ocular discharge, a Schirmer’s tear test (STT) should be performed</td>
</tr>
<tr>
<td>Focal corneal edema</td>
<td>Often indicates corneal surface (epithelial) disease (Figure 1)</td>
</tr>
<tr>
<td>Lateral perilimbal cornea; raised plaque</td>
<td>Most common location for dense cellular infiltrate and corneal vascularization seen in CSK and FEK; in more advanced cases, will spread medially</td>
</tr>
</tbody>
</table>

---

**FIGURE 10.** Superficial corneal vessels in a dog with superficial nonulcerative keratitis. Note that the vessels are arising from the conjunctival vasculature and form a branching “tree-like” pattern. Schirmer’s tear testing, fluorescein staining, and careful examination for underlying causes are essential whenever superficial corneal blood vessels are noted. Courtesy University of California–Davis Comparative Ophthalmology Service

**FIGURE 11.** Deep corneal vessels in a dog with uveitis and glaucoma. Note that the vessels are “hedge-like.” In this patient, vessels were present for 360 degrees around the limbus. Deep corneal vessels should stimulate a thorough intraocular examination, including measurement of intraocular pressure. Courtesy University of California–Davis Comparative Ophthalmology Service
QUESTION 3. WHY DID THE CORNEAL OPACITY OCCUR?

Given the wide variety of causes of corneal opacities and the knowledge that treatment for one cause can be contraindicated for other conditions, it is critical to determine the etiology of all corneal lesions. For example, topical steroids often are required to control immune-mediated keratopathies, but they are contraindicated for corneal ulcers because steroids slow healing, worsen keratomalacia, and predispose to infection.

In some instances, the appearance or location of a corneal opacity is pathognomonic or highly diagnostic. For example:

- **Dendritic ulcers** are considered pathognomonic for herpesviral infections, while circular translucent or “lacy” collections of dark brown-black melanin on the corneal endothelial surface are highly suggestive of a ruptured uveal cyst.
- **Dogs that blink poorly or sleep with their eyelids slightly open often have axial corneal fibrosis, vascularization, and melanosis, which are characteristic of exposure keratitis.**

In other patients, systemic signs may also provide useful hints regarding the cause of ocular signs; therefore, a thorough history is essential. For example, recent upper respiratory signs, stress, or immunosuppression in cats with keratitis, conjunctivitis, or both raises suspicion of an infectious cause, such as FHV-1.

And in other patients, historical data are critical; for example, worsening of a chronic keratitis during summer months might suggest UV involvement and a diagnosis of CSK.9

Ophthalmic Examination

A complete ophthalmic examination (and general physical examination, if systemic causes are suspected) is essential to identify related ocular and systemic abnormalities that may have led to the corneal opacity. In particular, anatomic or functional eyelid abnormalities, such as lagophthalmos, distichiasis, eyelid tumors, blepharitis, facial nerve paralysis, or conjunctival foreign bodies, should be carefully ruled in or out.

Cytology

Samples for cytologic assessment—obtained using the blunt end of a scalpel blade, Kimura spatula, or cytobrush—and aerobic bacterial ± fungal culture are excellent means to differentiate immune-mediated from infectious processes, and form the minimum database for investigation of corneal disease.

Ophthalmic Diagnostic Tests

**Tonometry & Ultrasound.** Diffuse corneal edema, deep corneal vessels, or episcleral injection are each indications of intraocular disease, and tonometry (measurement of intraocular pressure) and ocular ultrasound (if a complete intraocular examination is not possible) are recommended to assess for evidence of glaucoma, uveitis, intraocular masses, retinal detachment, or lens luxation.

**Schirmer’s Tear Test.** Presence of conjunctivitis and mucoid discharge combined with superficial corneal blood vessels, fibrosis, or melanin (in various combinations) are strongly suggestive of KCS, and a Schirmer’s tear test (STT) should always be performed.

**Palpebral Reflex.** An absent or decreased palpebral reflex predisposes to corneal exposure; a full neurologic examination, especially of cranial nerves, is warranted.

**Fluorescein Stain.** Any patient with corneal opacity should have fluorescein stain applied topically to assess for corneal ulceration. This evaluation should be performed after all other assessments are finished since it masks many other examination findings, and affects results of other tests, such as the STT, corneal cultures, and cytology.

When fluorescein is retained by the cornea, the character of the fluorescein staining pattern should be assessed because some patterns are highly suggestive of etiopathogenesis. For example:

- **Superficial chronic corneal epithelial defects** (SCCEDs)—also known as indolent or Boxer ulcers—classically leak fluorescein stain under nonadherent ulcer edges creating a “halo” effect.
- **Herpetic ulcers** sometimes have a pathognomonic dendritic pattern.
- **Deep ulcers** have staining of both their walls and floor.
- **Descemetoceles** stain only around the wall, creating a “donut” pattern of stain retention.2

QUESTION 4. WHEN DID THE CORNEAL OPACITY OCCUR?

Naturally, history is one of the most valuable tools to establish the duration of a corneal opacity, but other clues are available through examination. For example:

- **Acute corneal opacities** (< 3–5 days) do not have corneal vessels unless the vessels were present prior to the current lesion. It is estimated that corneal vessels first appear approximately 4 days after the initial corneal injury; then grow approximately 1 mm per day.
Active lesions usually have more irregular, or fuzzy, outlines due to corneal edema and/or cellular infiltrates.

Chronic, inactive lesions, such as corneal fibrosis or melanosis, often have more distinct borders with the surrounding cornea.

**QUESTION 5. WHEN SHOULD YOU REFER A PATIENT WITH A CORNEAL OPACITY TO A VETERINARY OPHTHALMOLOGIST?**

Although individual practitioners have different comfort levels regarding diagnosis and treatment of ocular conditions, certain conditions warrant referral to a veterinary ophthalmologist. Veterinarians should refer patients when:

1. They do not feel comfortable managing the ophthalmic condition
2. Referral is specifically requested by clients
3. Intraocular disease, a complicated (deep or chronic) corneal ulcer (Table 3), or vision impairment is present
4. Patients require corneal microsurgery

Corneal opacities that are suggestive of intraocular disease include diffuse corneal edema and deep corneal vessels; often in association with episcleral injection.

Referral to a veterinary ophthalmologist should take place as early as possible, in order to increase the chance of saving the eye, including its vision.

**TABLE 3. Determining Whether a Corneal Ulcer Is Complicated**

A corneal ulcer is considered complicated if one or more of the following is noted:

- Corneal blood vessels
- Corneal stromal loss (if > 50% is lost, surgical stabilization is typically recommended.)
- Corneal WBC infiltration (greenish yellow cornea)
- Failure to heal within 1 week
- Indolent ulcers (ie, SCCEDs)
- Infection
- Keratomalacia (“melting”)
- Marked or persistent corneal edema

References

Diagnosis & Treatment of Corneal Lesions

Ann R. Strom, DVM, MS, and David J. Maggs, BVSc, Diplomate ACVO
University of California–Davis

The corneal opacities described in this diagram are often seen in various combinations, sometimes with other corneal color changes (such as black, tan, or red). As such, the flowchart is simplified. If the reader has doubts about management of an ophthalmic case, they should consult with a veterinary ophthalmologist.

C/S = culture & sensitivity; IOP = intraocular pressure; NaCl = sodium chloride; PCR = polymerase chain reaction; SCCED = superficial chronic corneal epithelial defect; STT = Schirmer's tear test; US = ultrasound; WBC = white blood cell

---

The corneal opacities described in this diagram are often seen in various combinations, sometimes with other corneal color changes (such as black, tan, or red). As such, the flowchart is simplified. If the reader has doubts about management of an ophthalmic case, they should consult with a veterinary ophthalmologist.

C/S = culture & sensitivity; IOP = intraocular pressure; NaCl = sodium chloride; PCR = polymerase chain reaction; SCCED = superficial chronic corneal epithelial defect; STT = Schirmer's tear test; US = ultrasound; WBC = white blood cell
Ann Strom, DVM, MS, is a staff veterinarian in the University of California-Davis Comparative Ophthalmology Service. Her professional interests include all aspects of ocular disease and surgery, advanced diagnostic imaging, and comparative vision research. Dr. Strom received her DVM from University of Copenhagen, Denmark, and completed her MS at University of Zurich, Switzerland, a 1-year internship in small animal medicine and surgery at University of Saskatchewan, and a 3-year residency in comparative ophthalmology at University of California-Davis.

David Maggs, BVSc, Diplomate ACVO, is a professor in the University of California-Davis Comparative Ophthalmology Service. Dr. Maggs’ special interests include ophthalmic surgery and ocular surface disease, particularly feline herpesvirus. He is the author of Slatter’s Fundamentals of Veterinary Ophthalmology, serves on the editorial board of the Journal of Feline Medicine and Surgery, and is president elect of the International Society of Veterinary Ophthalmology. Dr. Maggs received his veterinary degree from University of Melbourne, Australia, and completed small animal and equine internships at Colorado State University and a research fellowship and comparative ophthalmology residency at University of Missouri.