MODERN CLINICAL OPTOMETRY
THE DIAGNOSIS AND TREATMENT
OF POSTERIOR CORNEAL DISORDERS

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Clinical Evaluation of the Cornea

- Patient History
- Slit-Lamp Biomicroscopy
- Corneal Topography
- Corneal Pachymetry
- Specular Microscopy
- Anterior Segment Imaging
- External Ocular Photography

Clinical Signs of Corneal Disease

- Presence of corneal epitheliopathy
- Presence of corneal endotheliopathy
- Abnormal stromal hydration
- Abnormal stromal thickness
- Loss of stromal transparency
- Stromal vascularization
- Abnormal corneal shape

Normal Corneal Endothelium

Primary function of the endothelium is to maintain the health and transparency of the corneal stroma.

Specular Microscopy

- Noninvasive photographic technique that allows you to visualize and analyze the corneal endothelium
- Uses computer-assisted morphometry to analyze the size, shape, and population of the endothelial cells
- Specular microscope captures the image reflected from the optical interface between the corneal endothelium and the aqueous humor
- The image is analyzed by the computer and displayed as a specular photomicrograph

Morphologic Endothelial Abnormalities

1. An abnormal rate of polymegethism
2. The presence of pleomorphism
3. The appearance, enlargement or coalescence of corneal guttata
4. Abnormal reductions in endothelial cell density


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Rate of Polymegethism

Complete coverage of the posterior corneal surface is required to maintain the barrier function and the active transport mechanism of the endothelium.

Central cornea loses 100 to 500 endothelial cells per year (0.5%).

Repair of the endothelial mosaic relies on cell migration and fusion. The movement of the cells creates variations in cell size known as polymegethism.

Abnormal rate indicates an overactive wound repair mechanism.

CV values from 22 to 31 are normal.
CV values from 32 to 40 are elevated.
CV values above 40 are abnormal.

Corneal Guttata

70% of population over 40-years-old.
Focal accumulations of extracellular collagen secreted by "stressed" endothelial cells.
Natural history includes five stages of severity.
Increased incidence with previous eye disease.

Specular Photomicrograph of Posterior Cornea

Electron Photomicrograph of Posterior Cornea

Corneal guttata are secretions of collagen from the endothelial cells that form a nodularity on the posterior surface of Descemet's membrane.

Stage 1 – The gutta nodule appears as a small dark structure in the center of an endothelial cell.
Stage 2 – The nodule may be almost the same size as an endothelial cell. In more advanced presentations, the endothelial cells surrounding the guttae nodules have a stretched appearance.
Presence of Pleomorphism

- In the normal corneal endothelium, more than 60% of the cells are six-sided.
- Hexagonal shape is best for maintenance of the barrier function.
- An endothelium with less than 50% six-sided cells is considered to be pleomorphic.

Abnormal Reduction in Cell Density

- The minimum number of cells needed to maintain corneal hydration is the Critical Cell Density.
- Advanced age, disease and injury may produce abnormal reductions.
- Asymmetry of more than 280 cells/mm² between the eyes is clinically significant.

Corneal Endotheliopathies

- Fuch’s endothelial dystrophy
- Contact lens-induced corneal endotheliopathy
- Secondary corneal edema: glaucoma-induced
- Secondary corneal edema: cataract surgery
- Secondary corneal edema: inflammation-induced

Fuch’s Endothelial Dystrophy

- Most severe primary corneal endotheliopathy.
- Affects 4% of the population over 40 years old.
- Characterized by a progressive loss of endothelial cell structure and function.
- Physiological malfunction increases the secretion of the collagen matrix that comprises Descemet’s membrane.
- These abnormal secretions form severe corneal guttata on the posterior surface of Descemet’s membrane.
- Fuch’s = progressive guttata + increased thickness.

Clinical Evaluation of the Cornea

- Loss of Transparency
- Endothelial Pigment
- Corneal Guttata

Stage 2 Fuch’s Endothelial Dystrophy
Fuch's Endothelial Dystrophy

52-year-old female

- Normal central corneal appearance with direct beam slit-lamp illumination
- Best corrected visual acuity is 20/25 in each eye
- Patient medical history is non-contributory

Stage 2 Fuch's Dystrophy

Fuch's Endothelial Dystrophy

52-year-old female

- Patient complains blurred vision and fluctuating vision
- Associated symptoms include difficulty reading at near with her current prescription
- No halos around lights
- Mild photophobia

Stage 2 Fuch's Dystrophy

Corneal Guttata

52-year-old female

- Abnormal corneal appearance with specular reflection slit-lamp illumination
- Presence of corneal guttata on the posterior surface of Descemet's membrane
- Stage 2 Fuch's

40x Magnification

Specular Microscopy

52-year-old female with Stage 2 Fuch's Dystrophy

Stage 4 Corneal Guttata
Stage 3 Corneal Guttata

Specular Microscopy – 1 year later

53-year-old female with Stage 2 Fuch's Dystrophy

Stage 4 Corneal Guttata
Stage 3 Corneal Guttata

Fuch's Endothelial Dystrophy

72-year-old male with 20/400 visual acuity in the left eye

- Minor ocular discomfort
- Severe loss of endothelial cell structure and function
- Severe stromal edema
- Severe epithelial edema
- Patient wants to know if new eyeglasses will help

Bullous keratopathy
Fuch's Endothelial Dystrophy

- Mild Loss of Transparency
- 72-year-old male with 20/25 visual acuity in the right eye
- No ocular discomfort
- Severe loss of endothelial cell structure and function
- Mild stromal edema
- No epithelial edema
- Patients has no visual complaints in this eye

Specular Microscopy

- Stage 2 Fuch's Dystrophy
- Coalescence of the corneal guttae increases to a point that the tessellation of the endothelial mosaic is difficult or impossible to visualize
- Collagenous material deposited on the posterior surface of the cornea appear as bright structures on specular microscopy

Contact Lens-Induced Endotheliopathy

- 37-year-old female
- Contact lens wear produces both acute and chronic morphologic changes in the corneal endothelium
- Rate of polymegethism increases as the span of contact lens wear increases
- Presence of pleomorphism increases as the span of contact lens wear increases

Corneal Neovascularization

- Abnormal peripheral corneal appearance with direct beam
- Superficial corneal neovascularization @ 2:00 on the left cornea
- Mild loss of corneal transparency in the area of neovascular encroachment

- 16x Magnification

- 25x Magnification
Specular Microscopy

37-year-old female
- Contact lens wear can affect the structure and function of the corneal endothelium
- Normal appearance of central cornea
- Abnormal corneal endothelium based on morphologic analysis performed by specular microscopy

Contact Lens-Induced Corneal Endotheliopathy

Specular Microscopy

37-year-old female
- Abnormal rate of polymegethism (CV above 40)
- Presence of pleomorphism (6A below 50%)
- Abnormal reduction in endothelial cell density (CD below 2400)

Contact Lens-Induced Corneal Endotheliopathy

Postoperative Corneal Edema

- Surgical trauma generally results in a 4-10% loss of cells
- Risk factors for a higher percentage of postoperative cell loss include pre-existing endothelial disease, diabetes, glaucoma, shallow anterior chamber and previous ocular surgery

Abnormal stromal transparency two weeks after cataract surgery

Chronic Postoperative Corneal Edema

- Complicated cataract surgery three years earlier
- Resolved pseudophakic bullous keratopathy
- Best corrected visual acuity is 20/40
- Patient is monocular and has advanced glaucoma
- Prescribe hyperosmotics

Abnormal Stromal Transparency

Specular Microscopy

87-year-old female
- Severe reduction in endothelial cell density
- Confluent corneal guttata
- Increased corneal thickness reveals abnormal stromal hydration
- Accelerated rate of cell loss for at least ten years after cataract surgery (2.5% vs 0.5%)

Iatrogenic Endotheliopathy

Preoperative Risk Assessment

- Have slit-lamp evidence of an endothelial dystrophy (e.g., corneal guttata)
- Have slit-lamp evidence of corneal edema
- Are about to undergo a surgical procedure associated with a high risk to the corneal endothelium

Slit-Lamp Evidence
**Preoperative Risk Assessment**

<table>
<thead>
<tr>
<th>Endothelial Functional Reserve</th>
<th>Endothelial Functional Reserve Ability</th>
<th>Risk of Chronic Postoperative Corneal Edema</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 2000 cells/mm²</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>1000 – 2000 cells/mm²</td>
<td>Adequate</td>
<td>Moderate</td>
</tr>
<tr>
<td>700 – 1000 cells/mm²</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>500 – 300 cells/mm²</td>
<td>Minimum</td>
<td>High</td>
</tr>
<tr>
<td>Below 300 cells/mm²</td>
<td>None</td>
<td>High</td>
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**Inflammation-Induced Endotheliopathy**

- Iridocyclitis causes a release of immune response proteins into the anterior chamber that leads to endothelial cell death
- Specular microscopy may reveal several well-demarcated dark structures

**Clinical Evaluation**

- 43-year-old man
  - Fibrin membrane partially obscuring left pupil
  - 20/50 best distance visual acuity in the left eye
  - IOP measures 10 mmHg in the right eye and 8 mmHg in the left eye
  - In office cycloplegia
  - Prescribe Pred Forte QID, one medrol dose pack, cyclogyl 1% BID

**Specular Microscopy – 16 months later**

- Rate of Polymegethism increased 27%
- Hexagonally-shaped cells decreased 33%
- Numerous Dark Structures
  - Corneal Edema

**Secondary Corneal Edema**

- 43-year-old male
- Abnormal symptoms - 3 days
- Redness of the left eye
- Eye pain in the left eye
- Photophobia in the left eye
- Tenderness in the left eye
- Blurred vision in the left eye
- Ocular history is significant for previous episodes of anterior uveitis

**Inflammation-Induced Endotheliopathy**

- 42-year-old male
  - Inflammatory cells can penetrate the tight junctions between endothelial cells and cause them to slough off the endothelium
  - Dislodged cells float free in the aqueous

**Anterior Uveitis**

- Fibrin membrane partially obscuring left pupil
- 20/50 best distance visual acuity in the left eye
- IOP measures 10 mmHg in the right eye and 8 mmHg in the left eye
- In office cycloplegia
- Prescribe Pred Forte QID, one medrol dose pack, cyclogyl 1% BID

**General Medical Observation**

- Inflammation-Induced Endotheliopathy
Anterior Segment Imaging

<table>
<thead>
<tr>
<th>Normal Right Cornea</th>
<th>Diffuse Stromal Edema</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corneal Thickness = 494 microns</td>
<td>Corneal Thickness = 592 microns</td>
</tr>
<tr>
<td>17% thicker than the right cornea</td>
<td></td>
</tr>
</tbody>
</table>

Specular Microscopy – 3 days later

- Resolving inflammation-induced endotheliopathy
- Resolving corneal edema secondary to recurrent anterior uveitis
- Reduction in white blood cells attached to the corneal endothelium
- Reduction in corneal thickness from 636 microns to 592 microns

43-year-old man

Secondary Corneal Edema