Examination of the Angle of the Anterior Chamber

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Introduction
Knowledge of the anatomy and pathology of the anterior chamber angle is critical for the accurate diagnosis and effective treatment of glaucoma. Examination of the angle helps differentiate open-angle from closed angle glaucoma thus choosing the proper line of treatment. Also it allows the performance of goniosurgery and laser trabeculoplasty.
In order to identify the structures seen during gonioscopy, one has to know the anatomy of the angle.

Anatomy of the Angle of the Anterior Chamber
The angle of the anterior chamber extends for 360° and is bounded between the back of cornea, small part of the sclera, part of the anterior surface of the ciliary body and the periphery of the iris. The aqueous humour finds its way out of the eye mainly through the trabecular meshwork found in the angle of the AC. (Figure 1)
The trabecular meshwork is bounded anteriorly by Schwalbe's line and posteriorly by the scleral spur.
The Schwalbe's line (composed of collagen and elastic tissue) runs circumferentially around the globe. This line marks the transition from trabecular to corneal endothelium. The scleral spur is a wedge-shaped fibrous ring which projects from the inner aspect of the anterior sclera. The longitudinal portion of the ciliary muscle is attached to the scleral spur.
The angle of the anterior chamber. The trabecular meshwork (2) is bounded anteriorly by the Schwalbe’s line (1) and posteriorly by the scleral spur (3). Aqueous humour passes from the anterior chamber (AC) through the opening of the trabecular meshwork to reach the canal of Schlemm (4). Ciliary processes (5) are seen crossing the angle recess.

In meridional section, the trabecular meshwork has a triangular shape, with its apex at the Schwalbe’s line and its base at the scleral spur. The meshwork consists of a stack of flattened perforated sheets. The sheets are fused in such a manner that only two or three layers are seen anteriorly, whereas 12 to 20 layers are detected posteriorly. The inner layers of the trabecular meshwork border the anterior chamber and are referred to as the uveal meshwork. The outer layers, the corneoscleral meshwork, are separated from the endothelium of the Schlemm’s canal by a thin strip of connective tissue called the juxtacanalicular tissue.

The uveal meshwork is formed of strands that arise from the anterior surface of the iris, bridging the angle recess, and insert into the deeper uveal trabeculae or Schwalbe’s line. These strands are a normal variant and have been given a variety of names, including iris processes, uveocorneal fibres and other names.

The corneoscleral meshwork consists of perforated sheets. These perforations are elliptical in shape and become progressively smaller from the superficial layers (close to the AC) to the deep layers (close to the canal of Schlemm). The perforations are not aligned, so aqueous humor must follow a circuitous route to reach the canal of Schlemm. These sheets are formed of bands that have a central core formed of collagen and a covering layer of endothelial cells.

The juxtacanalicular tissue is a thin layer of tissue that separates the outer layers of the corneoscleral meshwork from the inner wall of canal of Schlemm. Most of resistance of aqueous outflow is encountered within this layer.

The canal of Schlemm is an endothelial-lined circular channel that runs circumferentially around the globe. Septae run from the external wall to the internal wall and may provide some support for the canal.
The endothelial lining is formed of a single layer of cells. The endothelial cells of the inner wall of the canal have nuclei and a series of large vacuoles that form projections into the lumen of the Schlemm's canal. Some authorities believe these giant vacuoles serve as a pathway for fluid movement.

**Collector channels** arise from the outer wall of the canal of Schlemm and drain aqueous into a complex system of intrascleral, episcleral and subconjunctival plexuses.

In the adult normal angle, the iris is seen to dip down as its base is inserted into the ciliary body. The depth of the dip is known as the **angle recess**.

**The ciliary body band** seen at the bottom of the angle recess can vary in width, depending on the position of the iris insertion. Its color can vary from dull brown to pale gray.

**Equipment and techniques**

The anterior chamber angle can be visualized using direct and indirect techniques of gonioscopy. Direct gonioscopy is performed with a domed goniolens (e.g. Koepppe). The lens is placed on the anaesthetized eye with patient in the supine position. The space between the lens and the cornea is filled with saline or methylcellulose.

Direct gonioscopy is cumbersome and time consuming, that is rarely used as a diagnostic tool, but is essential during surgical procedures such as goniotomy and goniosynechiolysis.

Indirect gonioscopy is performed with goniolenses containing one or more mirrors with the patient sitting up at the slit lamp, providing an inverted image of the opposite angle. Two different styles of goniolenses, Goldmann and Zeiss type can be used for indirect gonioscopy. The Goldmann lens provides high magnification and excellent view of angle details, keeps the globe stationary, and affords better control during examination. It is ideal for learning gonioscopy and performing laser treatment to the angle of the anterior chamber. It is applied using methylcellulose. It has a diameter larger than that of the cornea. If extra posterior pressure is applied, indentation of the sclera may occur with false narrowing of the angle. If Descemet's folds are present in a non-hypotonous eye, they are most likely caused by excessive rotatory pressure on the lens. (Figure 2a)

The Zeiss lens requires only the natural tear film for coupling. Because there is no adherence between this goniolens and cornea, greater patient cooperation and examiner skillfulness are necessary to maintain optimal ocular and lens positioning. (Figure 2b)
The Zeiss lens enables rapid examination. It should be applied first with the eye in primary gaze, and should touch the cornea gently without producing folds of Descemet’s membrane. Some eyes have a tendency to drift away from the primary gaze position, but this goniolens can be easily removed or repositioned. The Zeiss lens is ideal for indentation gonioscopy. It has a diameter less than that of the cornea. It can be used to indent the cornea, displacing aqueous humour from the centre of the anterior chamber into the periphery and moving the peripheral iris posteriorly and artificially widening the anterior chamber angle. Indentation gonioscopy is used to determine if the closure of the angle is just appositional or irreversible synechial (Figure 3).

On performing gonioscopy doctors usually follow the following three steps, first identify the angle structures, then perform grading of the angle and finally look for abnormalities that may be encountered.

(1) Identification of the normal structures (Figure 4).

The Schwalbe’s line is an important gonioscopic landmark. With indirect goniolens the corneal parallelepiped of the slit lamp beam comes together at this point The scleral spur is seen gonioscopically as a gray-white line of varying width at the outer end of the angle recess. It is the point of termination of most of the iris processes. If blood is in Schlemm’s canal, it lies just anterior to the spur. The trabecular meshwork lies between the Schwalbe’s line and the scleral spur. Gonioscopically it has an irregularly roughened surface.
Indentation gonioscopy can differentiate appositional closure of angle from synechial closure.

This roughness is caused by the large openings of the uveal meshwork. It should be stressed that the examiner’s gaze should parallel the iris plane as near as possible when looking at the trabecular surface.

With indirect gonioscopy, having the patient look away from the viewing mirror gives an optimal view of the meshwork in wide-angled eyes. In narrow angled-eyes the convex plane of the iris forces a more oblique visualization (optimized with the patient looking toward the viewing mirror), which allows the angle recess to be seen, but may give somewhat distorted appearance to the meshwork. After identification of angle structures, one has to observe the following:

(a) Iris contour
(b) Angle width
(c) Structures visible

The Schwalbe’s line is an important landmark. With indirect goniolens, the corneal parallelepiped of the slit lamp beam comes together at this point.

The iris contour:

The iris contour can be slightly convex, very convex, flat, or concave. (Figure 5)

A slight convexity of the iris is seen in the majority of normal adult eyes. It is due to the pushing forward of the pupillary portion of the iris by the anterior surface of the lens and the slight ballooning forward of the periphery of the iris caused by a physiological difference in pressure between posterior chamber and anterior chamber.

The pressure in the posterior chamber ordinarily is slightly greater than that in the anterior chamber because of the small resistance aqueous encounters in flowing through the area of contact of iris and lens. This convexity is lost when a hole is made in the periphery of the iris.
A **convex iris** contour is typically seen in hypermetropic eyes, which have small anterior segment. A **flat iris** contour and in exceptional cases, even a slight concavity, is observed in myopia and aphakia. When the iris is flat, one should note where the plane of the iris lies in relation to the structures in the angle. In myopic and aphakic eyes, this plane generally lies well back to the level of the scleral spur. However in cases of plateau iris, the root of the iris is attached just behind the scleral spur and the plane of the iris is even further forward, sometimes at the level of the anterior trabecular meshwork or Schwalbe’s line. A **concave iris contour** may be associated with pigment dispersion syndrome, pigmentary glaucoma, old posterior uveitis and contraction of inflammatory tissue behind the iris.

**Figure 5:**
Iris contour can be slightly convex (1) flat (2) or concave (3).

**Figure 6:**
One estimates the width of the angle by examining the distance between Schwalbe’s line and the nearest part of the iris.

**Angle width:**
One estimates the width of the angle by examining the distance between Schwalbe’s line and the nearest part of the iris. (Figure 6)
The angle may be described as wide, intermediate, narrow, excessively narrow or closed. The width of the angle normally varies about the circumference, usually narrowest at the 12 o’clock position.

**(2) Grading systems of the angle**
Gonioscopic examinations are documented in a standardized fashion to accurately reflect findings and detect changes. The most commonly used gonioscopic grading systems have been described by Scheie, Shaffer and Spaeth.
Scheie's system is based on the extent of anterior chamber angle structure that can be visualized.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Visible structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide opened</td>
<td>All structures visible</td>
</tr>
<tr>
<td>Grade 1</td>
<td>Hard to see over iris root into recess</td>
</tr>
<tr>
<td>Grade 2</td>
<td>Ciliary body band observed</td>
</tr>
<tr>
<td>Grade 3</td>
<td>Posterior trabeculum observed</td>
</tr>
<tr>
<td>Grade 4</td>
<td>Only Schwalbe's line seen</td>
</tr>
</tbody>
</table>

Shaffer's grading system *(Figure 7)*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Iris is against the trabecular meshwork</td>
</tr>
<tr>
<td>Slit</td>
<td>Iridocorneal angle &lt; 10°</td>
</tr>
<tr>
<td>Grade I</td>
<td>Iridocorneal angle of 10°</td>
</tr>
<tr>
<td>Grade II</td>
<td>Iridocorneal angle of 20°</td>
</tr>
<tr>
<td>Grade III</td>
<td>Iridocorneal angle &gt; 20° and &lt; 40°</td>
</tr>
<tr>
<td>Grade IV</td>
<td>Iridocorneal angle of 40°</td>
</tr>
</tbody>
</table>

Spaeth's grading system is based on:

1. **Angle width (10°-40°)** *(Figure 8a)*
2. **Configuration of the peripheral iris** *(Figure 8b)*

<table>
<thead>
<tr>
<th>S (steep)</th>
<th>f (regular)</th>
<th>q (queer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior convexity</td>
<td>Flat</td>
<td>Posterior concavity</td>
</tr>
</tbody>
</table>

3. **Site of iris insertion** *(Figure 8c)*

<table>
<thead>
<tr>
<th>Anterior</th>
<th>Behind</th>
<th>C</th>
<th>Deep</th>
<th>Extremely deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior to the Schwalbe's line</td>
<td>Behind Schwalbe's line</td>
<td>Scleral spur visible</td>
<td>Ciliary body visible</td>
<td>&gt; 1 mm CB</td>
</tr>
</tbody>
</table>
(4) Pigmentation of TM (viewing the 12 o'clock angle) (Figure 8d)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>+1</td>
<td>Just visible</td>
</tr>
<tr>
<td>+2</td>
<td>Mild</td>
</tr>
<tr>
<td>+3</td>
<td>Marked</td>
</tr>
<tr>
<td>+4</td>
<td>Intense</td>
</tr>
</tbody>
</table>

Figure 7:
Shaffer’s gonioscopic grading system.

Figure 8:
Spaeth’s gonioscopic grading system (a) Angle width. (b) Peripheral iris contour. (c) Iris insertion.
Figure 8 (cont'd):
(d) Pigmentation of trabecular meshwork at 12 o’clock position.

(3) Identification of abnormal structures.

a) Vascularization:
Normal blood vessels in the angle vary greatly from eye to eye but certain characteristics permit one to distinguish the normal from the abnormal with reasonable certainty. To become familiar with the characteristics of normal blood vessels that may be seen in the angle one has to review the anatomy of the blood supply of the anterior segment.

The major arterial circle lies in the ciliary body at the root of the iris. It is made of anastomoses between the anterior ciliary arteries (7 in number) and the long posterior ciliary arteries (2 in number). The anterior ciliary arteries run from the recti muscles toward the cornea and perforate the sclera 2-4 mm from the limbus to join the circulus major. Branches from the major arterial circle run radially in the iris toward the pupillary area, supplying the iris.
These vessels are embedded in the iris stroma; have a variable corkscrew form, influenced by the size of the pupil. These normal iris vessels have a covering of stroma and characteristically conform to a radial pattern, with little tendency to branch, anastomose or wander diagonally. Occasionally parts of these vessels may be seen gonioscopically when their stromal covering is not enough to hide them.

Occasionally portions of the major arterial circle are situated far forward on the surface of the ciliary muscle and may be seen anterior to the root of the iris on the ciliary band. Characteristically only short segments of the artery come into gonioscopic view and these always have a circumferential direction. In addition to the normal radial vessels of the iris and wandering portions of the circumferential artery of the ciliary body, a third type of vessels is seen occasionally in normal human angles, i.e., vertical vessels deep in the ciliary band, probably the anterior ciliary arteries, extending from the interior surface of the sclera, form an "emissary" passage, to the arterial circle in the ciliary muscle. These deep vertical vessels are visible in the ciliary band in eyes that are lightly pigmented and have thin, fairly transparent uveal tissue.

In rare instances, an anterior ciliary artery on the inner surface of the ciliary band extends straight forward, without branching to disappear into the sclera, usually just behind the scleral spur, with no connection with Schlemm's canal.

On the other hand abnormal vascularization may be encountered in the angle and on the surface of the iris. These vessels take unpredictable coil course, without either the distinct radial or the circumferential direction that is characteristic of the normal vessels. The new vessels are also distinguished from the normal vessels by the fact that they grow on the surface of the iris and not within the stroma. (Figure 9)

In some cases, neovascularization is restricted to the angle, at least at an early stage. Vessels extend from the junction of the iris and ciliary band onto the periphery of the iris and up the wall of the angle. On the wall, the vessels grow vertically over the ciliary band and scleral spur onto corneoscleral trabecular meshwork, where they arborize and often appear to dip into the filtration portion of the meshwork as if going to the Schlemm's canal.
b) Pigmentation in the angle:

In evaluating the pigmentation of the angle, one must distinguish pigment that is deposited from the brown uveal meshwork that is normally present in many eyes. Brown uveal meshwork typically occurs in the form of strands, or a network of strands, extending across the ciliary band and the scleral spur onto the posterior half of the corneoscleral meshwork. Deposited pigments, which have been carried by the aqueous humor to the trabecular meshwork, are characteristically located in a band overlying Schlemm’s canal in the filtering portion of the meshwork, roughly in its middle third. Pigment deposition in a solid band in the whole circumference is, in almost all instances, pathologic. The denser and broader the band, the more likely it is to be pathological. In an elderly patient, when extensive pigment deposition is seen in the angle, the first suspicion is exfoliation, which can readily be looked for under the pupillary border. In young individuals, before the age of nuclear sclerosis, excessive pigmentation in the trabecular meshwork suggests pigmentary glaucoma, in which there is degeneration of the posterior pigmented layer of the iris toward the mid-periphery, and no dandruff like exfoliation.

c) Peripheral anterior synechias:

The term peripheral anterior synechia (PAS) signifies a condition in which the iris has become attached further forward in the angle than normal; into the scleral spur, corneoscleral meshwork, Schwalbe’s line or even to cornea. (Figure 10a) PAS should not be confused with the normal uveal meshwork. The normal uveal meshwork is always has a lacy structure composed of a network of strands with openings and is porous in appearance. PAS differ in being more solid and in being definitely composed of iris stroma. Synechias take numerous characteristic forms, ranging from tiny tent-like adhesions to complete closure of the angle. (Figure 10b)
Figure 10:

(a) Peripheral anterior synechia.  
(b) Normal iris processes.

Figure 11 and 12 are examples of gonioscopic view of the angle of the anterior chamber.

Figure 11:
Gonioscopic view of a closed angle.

Figure 12:
Gonioscopic view of a widely opened angle.

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