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Gonioscopy in the Management of Glaucoma

James A. Savage, MD

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Learning Objectives

Upon completion of this module, the reader should be able to:

- Discuss the indications for performing gonioscopy
- Compare and contrast the three methods of gonioscopy
- Interpret gonioscopic findings
- Recognize anatomy and pathology of the anterior chamber

Key words: direct gonioscopy, glaucoma, gonioscopy, indirect gonioscopy

Introduction

Glaucoma is the term used to describe a family of diseases characterized by an optic neuropathy for which elevated intraocular pressure is a major risk factor. The individual entities that comprise this diverse group of conditions are distinguished from one another by the pathologic condition in the drainage angle of the anterior chamber responsible for decreased facility of aqueous outflow and elevated intraocular pressure. Therefore, *gonioscopy*, the visual inspection of the anterior chamber angle through a goniolens, is necessary to differentiate one type of glaucoma from another and guide decisions for appropriate therapy.

History

Trantas, using limbal indentation in an eye with keratoglobus in 1907, first visualized the anterior chamber angle in a living eye and coined the term *gonioscopy*. Salzmann later determined, in 1914, that because of total internal reflection of light, without special optical instrumentation the visualization of the angle was impossible in nearly all eyes. He determined that the majority of anterior chamber angles could be visualized with a contact lens having a steeper curvature than the cornea. With a lens of his own design, he made valuable observations and drawings of the normal and pathologic anatomy of the anterior chamber angle. During the first half of the twentieth century, modifications in gonioscopic technique were used by Troncoso, Koeppe, Goldmann, and others. Finally, in 1938, Barkan described the use of gonioscopy in the differentiation and classification of the glaucomas.

The three primary methods of gonioscopy in use today are Goldmann (indirect), indentation (dynamic/indirect), and Koeppe (direct) gonioscopy. These techniques were developed, respectively, by Goldmann in 1938, Forbes in 1966, and Koeppe in 1919. Each method has particular uses, advantages, and disadvantages (Table 1, page 2).

Optics

The incident angle of light reflected from the anterior chamber angle is greater than the critical angle at the cornea–air interface. As a consequence, total internal reflection prevents the direct visualization of the anterior chamber angle in nearly all eyes. To compensate for this optical inconvenience, contact lenses known as *goniolenses* are required to examine the anatomy of the angle. (Figure 1).

In the case of the indirect method, the problem of total internal reflection is overcome by a prism/mirror system and a viscous coupling solution or tears between the lens and the topically anesthetized cornea (Figure 2, page 2). The image of the anterior chamber

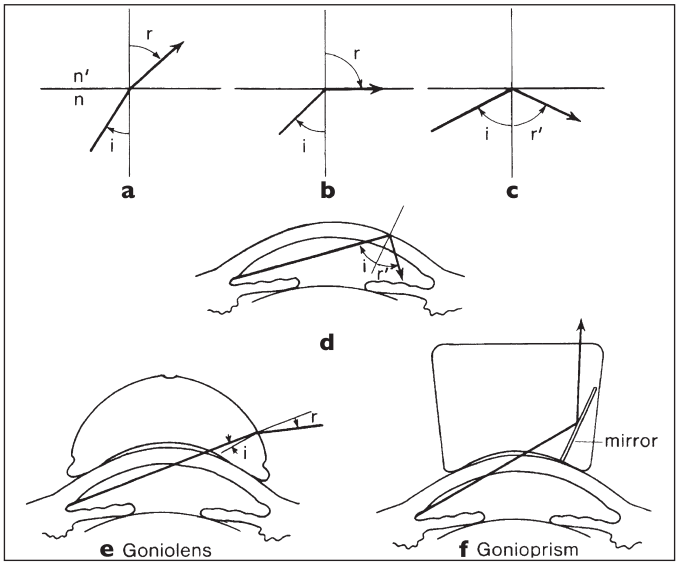

Figure 1. Optical principle of gonioscopy. Parts a, b, and c illustrate the refraction or reflection of light when it passes between two media with different indices of refraction (n and n′). When the angle of incidence (i) is less than the critical angle, light is refracted into the second medium (a). When the incident angle is equal to the critical angle (b), the light is refracted at 90°. When the incident angle is greater than the critical angle(c), the light is reflected back into the first medium. Because of the critical angle at the air–cornea interface, light from the anterior chamber angle is reflected back into the eye (d). To overcome this optical inconvenience and make the angle structures visible, contact lenses with similar indices of refraction to the cornea are employed to allow light to enter the lens for visualization of angle structures (e and f). (Shields MB. Aqueous humor dynamics II: techniques for evaluating. In: Shields MB, *Textbook of Glaucoma,* 3rd ed. Baltimore: Williams & Wilkins; 1992:39.)

Table 1. Advantages and Disadvantages of Gonioscopic Techniques

Technique:	Koeppe (Direct)	Goldmann (Indirect)	Indentation (Indirect)
Advantages:	• An erect and panoramic view of the angle with excellent perception of spatial relationships, albeit with less magnification than with Goldmann or indentation methods performed at the slit lamp microscope. In this regard, Koeppe gonioscopy is analogous to indirect ophthalmoscopy and indirect gonioscopy is analogous to direct ophthalmoscopy. • Minimal or no distortion of the chamber angle. Therefore, it is an excellent method for evaluating the depth and potential for closure of the anterior chamber angle in its natural state. • Can be performed on both eyes simultaneously.	• Ease in learning technique and obtaining the necessary equipment. • Greater visibility of detail than with the Koeppe technique because of higher magnification. Therefore, it is better for detection of details such as subtle neovascularization in the angle. • Instrumentation more popular and readily available than that required for Koeppe gonioscopy.	• Allows quick evaluation of angle structures. • No coupling solution necessary. • Enables differentiation between appositional (reversible) and synechial angle closure. Greater visibility of detail than with the Koeppe technique because of higher magnification. Therefore, it is better for detection of details such as subtle neovascularization in the angle. • Instrumentation more popular and readily available than that required for Koeppe gonioscopy.
Disadvantages:	• Difficulty of learning technique. • Instrumentation expensive and difficult to obtain. • Less magnification so less detail visible than with indirect techniques.	• Tendency to overestimate the narrowness of the angle if the rim of the lens indents the limbus. • Tendency to underestimate the narrowness of the angle if the rim of the lens indents the cornea anterior to the limbus.	• Mastery of proper technique requires skill and practice. • Tendency to underestimate the narrowness of the angle; it is difficult to avoid inadvertently applying pressure to the central cornea, thus artificially widening the angle.

Figure 2. Application of viscous coupling agent to a Goldmann lens in preparation for gonioscopy.

angle is reflected in a mirror at a tilt of 59°–64° (62° most common). Therefore, the portion of the angle viewed is that opposite the mirror, 180° away. However, the up/down and left/right orientations remain the same (Figure 3). For example, when the mirror is centered at 12 o'clock, the 6 o'clock position is in the center of the mirror with the 5 o'clock position to its right and the 7 o'clock position to its left. Through the years, lenses with one, two, three and four mirrors have been devised, which permit visualization of the entire angle circumference with minimal necessity to rotate the lens. Some lenses have mirrors at varying tilts, 59°–64° for viewing the angle, and up to 80° for examination of the peripheral retina through a dilated pupil. In addition, through the center of the Goldmann-type lens, the posterior pole of the eye, including the macula and optic disc, is visible in valuable three-dimensional detail.

Goldmann Gonioscopy

The Goldmann lens is inserted by, first, applying topical anesthetic. The lower lid is then retracted inferiorly by the fifth finger of the hand holding the lens while the edge of the lens is used to engage and fully retract the lid downward, creating enough room between the upper and lower lids to allow the lens to be tilted onto

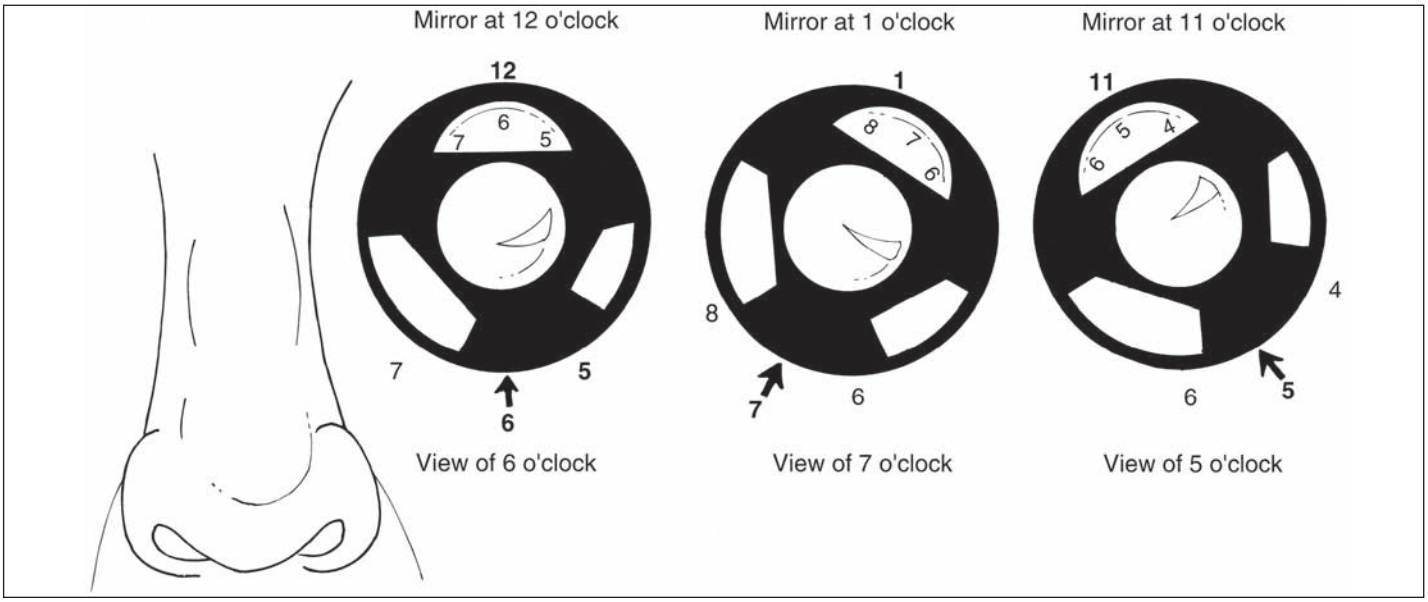

Figure 3. A mirrored goniolens such as a Goldmann or an indentation lens does not invert the image of the angle. This optical fact must be kept in mind when locating structures in the angle. For example, when the lens mirror is centered at 12 o'clock, the 6 o'clock image is in the center of the lens with the 5 o'clock to the right and the 7 o'clock to the left. (Grant WM, Schumann JS. The angle of the anterior chamber. In: *Chandler and Grant's Glaucoma*, Epstein DL, Allingham RR, Schumann JS, et al, eds. Baltimore: Williams & Wilkins; 1997:53.)

the surface of the cornea. A viscous coupling fluid (a hydroxypropyl methycellulose solution for ophthalmic use, eg, Gonisol) is necessary. The fluid may interfere with later examination of the fundus and other examinations (visual field, fundus photography).

Indentation Gonioscopy

Indentation or "dynamic" gonioscopy is an indirect method that works by the same optical principle as the Goldmann lens; that is, visualization through mirrors at the slit-lamp microscope (Figure 4). However, unlike the Goldmann technique, in indentation gonioscopy the area of contact of the lens with the corneal surface is restricted to the central cornea. This modification, developed and popularized by Forbes in 1966, is used to indent the central cornea, thereby displacing aqueous into the peripheral anterior chamber where it bows the iris posteriorly and widens the chamber angle. This widening differentiates areas where the peripheral iris is permanently adherent to the peripheral cornea in the form of peripheral anterior synechias, from areas where the iris is merely reversibly apposed to the peripheral cornea in an occludable angle (Figure 5, page 4). Another use for indentation gonioscopy is the identification of subtle cyclodialysis clefts.

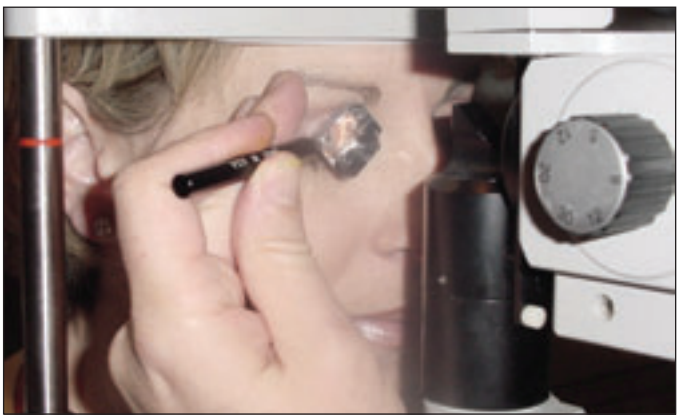

Figure 4. Application of an indentation goniolens at the slit lamp microscope. A viscous coupling agent is not required. Gentle indentation of the central cornea with this lens displaces aqueous from the central anterior chamber into the angle, pushing the iris posteriorly and widening the angle. This enables the examiner to, among other things, differentiate appositional from synechial angle closure.

Online Subscriber Video: Indentation Gonioscopy

The commonly used indentation lenses (Zeiss, Posner, and Sussman) have four mirrors with 64° tilt, spaced at 90° intervals (Figure 6, page 4). It is not necessary to apply a viscous coupling solution to these lenses although, as with all forms of gonioscopy, the cornea must be anesthetized.

Direct Gonioscopy

A dome-shaped, mirrorless lens is used in Koeppe (direct) gonioscopy. This technique, which is less often

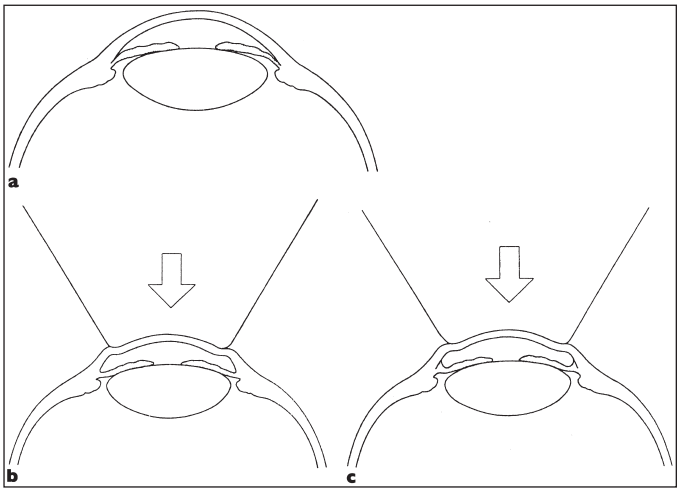

Figure 5. Differentiation of appositional from synechial angle closure with indentation gonioscopy. **a.** Cross section of an eye with angle closure. **b.** In an eye with appositional angle closure, an indentation goniolens is applied and used to gently indent the central cornea. This forces aqueous into the peripheral anterior chamber where it forces the peripheral iris posteriorly, thereby opening the angle. **c.** In this eye with synechial angle closure, the iris is adherent to the angle structures and indentation does not open the angle. (Wilensky J. Optics of gonioscopy. In: *Clinical Ophthalmology*. Tasman W. Jaeger EA, Caprioli J, eds, Philadelphia: Lippincott, Williams & Wilkins, Vol 1, 1998:5)

Figure 6. Examples of indentation goniolenses showing differences in sizes and handles. **a.** Zeiss. **b.** Sussman. **c.** Posner.

used than in the past, requires external hand-held illumination and magnification sources not always available in most ophthalmologists' offices. Figure 7 displays a typical Koeppe system in use. Because the lens

Figure 7. Koeppe gonioscopy technique. The patient is recumbent with lenses in place using a viscous coupling agent. The examiner holds an illuminator in one hand and a microscope in the other to obtain an upright, magnified view of the chamber angle.

is mirrorless, unlike Goldmann and indentation gonioscopy, the image is direct and upright. This method offers a panoramic, albeit less magnified, view of the angle than indirect gonioscopy performed at the slit-lamp microscope. Also, it is far less likely to exert pressure upon the cornea or limbus, causing artifactual widening or narrowing of the angle, than indirect gonioscopic techniques.

Some Koeppe lenses are designed with a central dimple on the anterior surface of the lens. This dimple facilitates gentle stabilization and rotation of the lens with the tip of a muscle hook for optimal visualization of the depths of the angle. Through a Koeppe lens *without* a central dimple, a direct ophthalmoscope can be used to visualize the optic disc and macula despite an undilated pupil and varying degrees of media opacity. This is a valuable nongonioscopic clinical use of the Koeppe lens.

Informational Goals

In situations such as secondary glaucoma, ocular trauma, and complicated intraocular surgery, gonioscopy is used to detect abnormalities in the angle such as neovascularization, peripheral anterior synechias, excessive pigmentation, and inflammatory precipitates. In the majority of situations, however, gonioscopy is used in the evaluation of primary glaucoma, either open angle or angle closure.

Three questions should be answered with gonioscopy when evaluating a patient for primary glaucoma:

- Is the angle open or closed in its natural position?

- If angle closure exists, is it appositional? (reversible) or synechial (permanent)?
- If open, is the angle occludable?

Determining Angle in Natural Position

Koeppe gonioscopy is the ideal method for observing the angle in its natural position. However, special instruments are required, so from a practical point of view—in terms of speed and efficiency—indirect gonioscopy is more convenient for most ophthalmologists. One should use the method with which he or she is most comfortable and confident. With the indirect Goldmann lens, if pressure is applied to the lens when its flange lies at the limbus, the angle may appear narrower than it actually is. However, if pressure is applied when its flange rests anterior to the limbus, just as with indentation ("dynamic") gonioscopy, the angle may be artificially widened. This may cause a closed or occludable angle to appear safely open. For this reason, application of the indirect lens must be gentle and indentation (dynamic) gonioscopy must be carefully performed.

It is important that the pupil not be dilated pharmacologically before the evaluation of angle width. Not only is there some risk of precipitating an acute attack of angle closure in a susceptible eye, but wide mydriasis can, in some cases, actually *decrease* the amount of relative pupillary block and, while the pupil is widely dilated, make an occludable angle appear safely open. (Maximal relative pupillary block usually exists when the pupil is at middilation. This explains the occasional case of precipitated angle closure occuring *after* the patient has left the office and the pupil reaches middilation hours after the office visit, as it slowly returns to its normal diameter.)

Determining Permanency of Angle Closure

Indentation gonioscopy, as described by Forbes, is a technique wherein one uses a four-mirror gonioprism (eg, Zeiss, Posner, or Sussman) with a small area of contact limited to the central cornea, to displace aqueous from the central to peripheral anterior chamber, artificially widening the angle. With this technique, areas of appositional angle closure in which the peripheral iris is resting upon, but is not yet adherent to, the trabecular meshwork are opened by bowing the iris posteriorly, away from the angle structures. However, areas of peripheral anterior synechias remain closed despite this maneuver (see Figure 5).

The extent of synechial closure is of critical importance because, following relief of relative pupillary block with iridectomy, the control of intraocular pressure depends, in large part, on the fraction of the trabecular meshwork's circumference not yet closed with synechias. Areas of synechial closure that remain closed following iridectomy and iridoplasty are unavailable for aqueous outflow except in certain cases when peripheral anterior synechias can be broken with laser gonioplasty or surgical goniosynechialysis. The ratio of appositional to synechial angle closure was a much more serious issue prior to the introduction of laser iridectomy in the 1970s. Before that time, *surgical* peripheral iridectomy was required to relieve pupillary block. With modern laser techniques, the effect of iridectomy can be assessed without intraocular surgery.

Determining Whether Angle Is Occludable

It is not always possible to determine with gonioscopy if an angle is definitely occludable. The examiner's judgment and experience play a large role. In cases with angles that appear suspicious, one is left with the option of proceeding with laser iridectomy or using other criteria, such as provocative testing, to try to assess the risk of future angle closure. As the crystalline lens volume increases due to age and progression of cataract, relative pupillary block increases. Therefore, an eye of questionable occludability will become even narrower as the patient ages. Because of the high degree of safety of laser iridectomy, at the present time, most ophthalmologists proceed with laser iridectomy in worrisome eyes rather than relying upon provocative testing.

Interpretation of Gonioscopic Findings

Grading Systems of Angle Width

Several grading systems have been used to describe the width of the anterior chamber angle and thus its potential for angle closure. Shaffer, Scheie, and Spaeth devised the three most commonly used systems.

The Shaffer system (Table 2, page 6) is based upon the angle between the cornea and peripheral iris and describes angle width on a scale from 0 to IV with 0 being "closed" and IV being "wide open" (an angle of 40° or more between the peripheral cornea and iris). The Scheie grading system (Table 3, page 6) uses a scale from I to IV but, unlike Shaffer's system, is

Table 2. Shaffer and van Herick Classifications of the Anterior Chamber Angle

Depth	Shaffer Classification*	van Herick Classification†
Partial or complete closure	Grade 0	—
≤10° angle of approach	Grade I	AC‡ < 1/4 CT§
20° angle of approach	Grade II	AC = 1/4 CT
20°–35° angle of approach	Grade III	AC = 1/2 CT
35°–45° angle of approach	Grade IV	AC ≥ 1CT

* Based upon the angle of approach into the angle. Caveats: Usually a good indicator of occludability but without mentioning the most posterior structure visible, theoretically, the angle could be entirely closed and be grade IV with a 40° approach.

† Based upon the depth of the peripheral anterior chamber as seen at the slit lamp. Caveats: This is not a direct examination of the angle and it can either over- or understate the occludability of the angle. Therefore, it should never be used as a substitute for gonioscopy.

‡ AC = peripheral anterior chamber depth as seen with oblique slit beam.

§ CT = corneal thickness as seen with oblique slit beam.

Table 3. Scheie Gonioscopic Classification of the Anterior Chamber Angle

Scheie Classfication	Comment
Grade 0	Entire angle visible as far posterior as a wide ciliary body band
Grade I	Last roll of iris obscures part of the ciliary body
Grade II	Nothing posterior to trabecular meshwork visible
Grade III	Posterior portion of trabecular meshwork hidden
Grade IV	No structures posterior to Schwalbe's line visible

* Based upon the most posterior structure visible in the angle. Caveats: Because this classification system does not deal with the issue of the angle of approach and, hence, occludability, the scleral spur could be visible for its entire circumference in an eye with an occludable angle.

based upon the most posterior structure visible in the angle. In this system, grade I signifies that the ciliary body is visible and that, therefore, the angle is almost certainly widely open and not occludable. A grade IV angle is closed. Obviously, care must be taken to specify which system is being used because a Shaffer grade IV angle is wide open and a Scheie grade IV angle is closed.

Spaeth has developed a detailed system of grading the width of the anterior chamber angle. Spaeth's system combines Shaffer's and Scheie's, creating a more complete and precise grading system. It considers three variables: (1) the point where the iris contacts the wall of the angle, (2) the angular approach of the iris to the angle recess, and (3) the configuration of the peripheral curvature of the iris (Table 4).

Regarding the most anterior point of iris contact with the drainage side of the angle, Spaeth's system uses the following scale: A = anterior to the trabecular meshwork, B = behind Schwalbe's line in the area of the trabecular meshwork, C = scleral spur, D = anterior ciliary body visible, and E = wide band of ciliary body visible. When the view of the actual insertion of the iris is blocked by iris, the apparent insertion is denoted by putting the letter in parentheses. The angle of approach is the angle between the angle wall and the iris one-third of the distance from the most peripheral portion of the iris. The configuration of the peripheral iris is described as follows: q = posterior bowing or concave iris, r = no significant forward or backward arching as the iris emerges from the angle recess, and s = convex forward bowing. The pigmentation of the trabecular meshwork is denoted on a scale 0–4 (0 = none, 1+ = just visible, 2+ = mild, 3+ = marked, and 4+ = intense). Therefore, an angle designated as "D40r 4+PTM" would mean a wide open, nonoccludable angle with the iris inserted into the ciliary body, a 40° angle of approach, a peripheral iris contour that is neither concave nor convex, and intensely pigmented trabecular meshwork.

Regardless of which system is used, the issue of angle width boils down to the questions posed earlier: Is the angle open or closed in its natural position? If closed, is it appositional or synechial closure? If open, is it occludable?

The width and occludability of the anterior chamber angle can be estimated at the slit-lamp microscope

Table 4. Spaeth Gonioscopic Classification of the Anterior Chamber Angle*

Point Where the Iris Contacts the Wall of the Angle		Angle of Approach	Configuration of the Peripheral Curvature of the Iris	
A	Anterior to the trabecular meshwork	0–40+°	q	Posterior bowing (concave)
B	Behind Schwalbe's line in the area of the trabecular meshwork		r	No significant forward or backward arching as the iris emerges from the angle recess
C	Scleral spur			
D	Mid-ciliary body (anterior ciliary body band visible)		s	Forward bowing (convex)
E	Posterior ciliary body (Wide band of ciliary body visible)			

* For example, an angle designated as "D40r" would be a wide open, nonoccludable angle with the iris inserted into the ciliary body, a 40° angle of approach, and a flat peripheral iris contour.

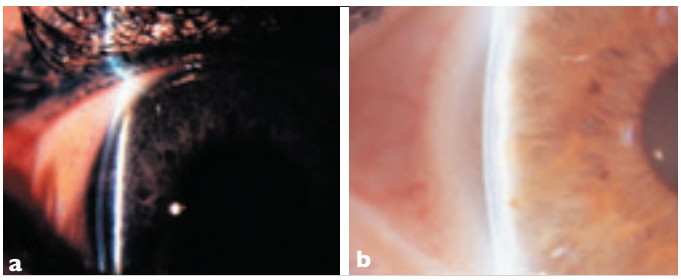

Figure 8. The van Herick technique of estimating anterior chamber angle depth. **a.** In this eye the depth of the peripheral anterior chamber is greater than one corneal thickness, and so the angle is likely to be wide open and not occludable. **b.** In this eye the chamber depth is less than one fourth of a corneal thickness and so the angle is likely to be closed or occludable.

with a technique described by van Herick (Figure 8). However, this technique is not foolproof and should *never* be used as a substitute for direct examination of the angle with gonioscopy. This slit-lamp technique consists of aiming a thin slit beam perpendicular to the cornea at the temporal limbus. The optical section thus created is viewed at a 60° angle and the visible thickness of the corneal section is compared to the depth of the anterior chamber, which is seen as the distance between the points where the slit beam leaves the posterior cornea and strikes the anterior surface of the iris. Obviously, the deeper the anterior chamber compared to the thickness of the cornea, the less likely it is to be closed or occludable. The Shaffer scale can be roughly compared to the van Herick method as follows: Shaffer grade I is analogous to a peripheral chamber depth less than one-fourth the corneal thickness, grade II to one-fourth thecorneal thickness, grade III to one-half the corneal thickness and grade IV to one or more corneal thicknesses (see Table 2). However, these are only approximations and, all too often, an eye that appears to have a wide-open angle at the slit lamp is occludable or even closed. Therefore, the van Herick technique should be used only to prompt the examiner to perform gonioscopy on eyes with shallow anterior chambers, even if the intraocular pressure is normal, but should never be used as a substitute for gonioscopy. The only way to assess the occludability of an angle is to look at it.

Anatomy and Pathology of the Anterior Chamber Angle

The components of the drainage angle are arranged along the wall of the peripheral cornea and anterior sclera (Figure 9, page 8). These structures are usually, but not always, identified by varying degrees of pigmentation and other biomicroscopic clues. These structures, as shown in a view through a goniolens, are best understood if they are correlated with a cross section of the angle as shown in Figure 10.

Online Subscriber Video: Normal Angle Structures

Schwalbe's Line. The most anterior structure in the angle is the termination of Descemet's membrane, Schwalbe's line. It is composed of a circumferential ring of collagen fibers. In certain situations such as Axenfeld-Rieger Syndrome it is prominent, anteriorly displaced and readily identified, even grossly or through the cornea during slit lamp biomicroscopy. The termination of the peripheral cornea fits into a groove in the anterior sclera. This anatomy leads to a valuable, infallible method of locating Schwalbe's line. If a narrow slit beam is projected obliquely into

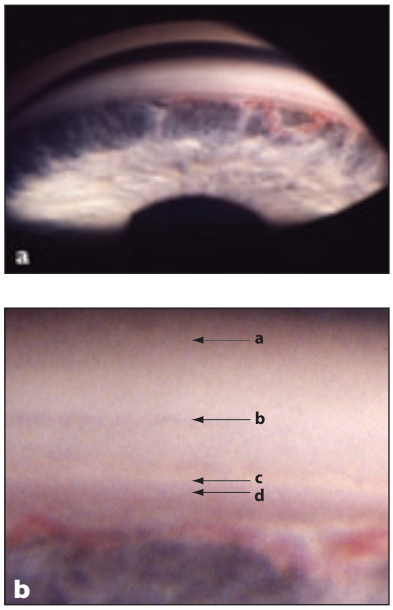

Figure 9. The anterior chamber angle. **a.** The normal angle. (cover illustration) **b.** Details of the structures including (a) Schwalbe's line, (b) trabecular meshwork, (c) scleral spur, (d) and ciliary body. (Photo courtesy of Darrell K. Henry)

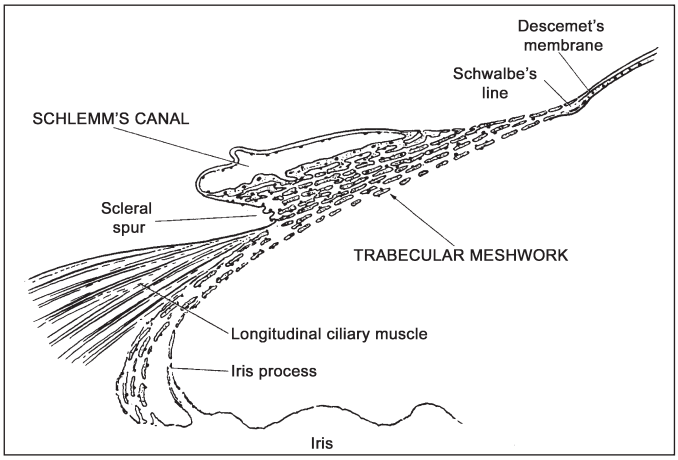

Figure 10. Cross section of normal angle anatomy. (Shields MB. Aqueous humor dynamics II: Techniques for evaluating. In: *Textbook of Glaucoma,* 3rd ed. Baltimore: Williams & Wilkins; 1992:16.)

the angle during gonioscopy, the slit beams striking the inner and outer surfaces of the cornea converge at Schwalbe's line (Figure 11).

Varying degrees of pigmentation may be found deposited on or anterior to Schwalbe's line. When present, this finding is called *Sampaolesi's line* and is especially prominent in cases of exfoliation syndrome. Varying amounts of pigment on Schwalbe's line are also seen in pigmentary dispersion syndrome and pigmentary glaucoma and following anterior segment

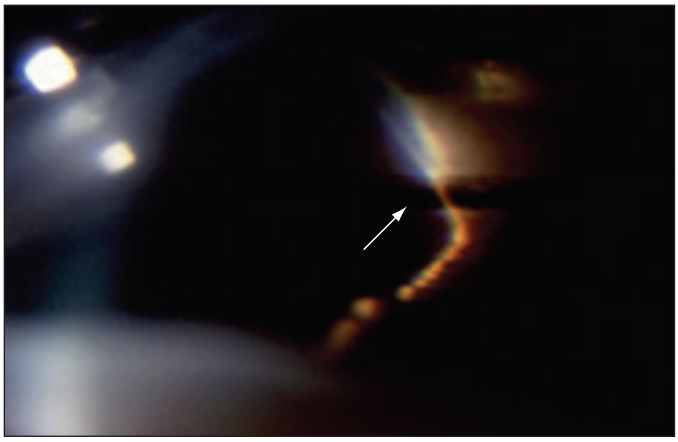

Figure 11. Precise identification of Schwalbe's line is possible by projecting a thin slit beam into the angle. The reflexes of the beam upon the inner and outer corneal surfaces converge at Schwalbe's line (arrow). This is especially useful in eyes with minimal pigment in the angle. (Photo courtesy of E. Michael Van Buskirk, MD)

laser procedures or intraocular surgery. However, in many cases the line is indistinct, especially when the adjacent trabecular meshwork has little or no pigmentation. In these cases, it is important to identify the location of Schwalbe's line. Otherwise one might assume that no angle structures are visible and make the incorrect diagnosis of angle closure. Conversely, pigment deposited upon Schwalbe's line may mimic the pigmentation of the trabecular meshwork and lead the examiner to interpret a closed angle to be open. Usually, however, pigmentation on Schwalbe's line can be distinguished from trabecular pigmentation by its characteristically discontinuous and "salt and pepper" appearance compared to the more confluent and tan appearance of the pigmented trabecular meshwork.

Trabecular Meshwork. The trabecular meshwork is located immediately posterior to Schwalbe's line. The anterior, nonpigmented meshwork plays a small role in aqueous outflow. The posterior, pigmented, meshwork is the primary site of aqueous outflow and is located just anterior to the scleral spur and interior to the juxtacanalicular tissue, which separates the meshwork from Schlemm's canal. The pigmented meshwork can be difficult to identify, depending upon the degree of pigmentation and how much of the scleral spur is obscured by the uveal meshwork. The pigmentation of the functional trabecular meshwork can vary greatly. It is unpigmented or dull gray at birth and later acquires increasing degrees of pigmentation. Therefore, it can remain relatively nonpigmented throughout life or have dense, nearly black, pigmentation in cases of pigment dispersion syndrome or pigmentary

glaucoma. The pigmentation may be confluent for the entire 360° circumference of the angle or irregular, with segments of pigmented meshwork interrupted by nonpigmented areas. When pigmentation is minimal or absent, blood is occasionally visible in Schlemm's canal, especially when episcleral venous pressure is increased, occasionally from pressure exerted by a gonio lens during gonioscopy, or upon application of pressure to the ipsilateral jugular vein. This can occasionally be used as a landmark in identification of angle structures in nonpigmented angles.

Scleral Spur. The scleral spur is a glistening white protuberance, an anterior extension of sclera between the ciliary body and trabecular meshwork. The ciliary muscle fibers attach to its posterior edge and trabecular beams to its anterior edge. The scleral spur is important to identify gonioscopically for orientation in angles with minimal pigmentation and, in narrow angles, to determine whether the posterior trabecular meshwork is unobstructed. It is usually visible as a bright white line between trabecular meshwork and ciliary body, but can be obscured by the uveal meshwork. In cases of blunt trauma in which the uveal meshwork is damaged and/or the ciliary muscle is detached, the scleral spur can assume an abnormally white and distinct appearance.

Uveal Meshwork. The uveal tissue is usually colorless and extends from ciliary body to Schwalbe's line, forming the inner wall of the trabecular meshwork. It has no functional significance and has no influence on facility of aqueous outflow. It is an important structure, however, to keep in mind when identifying the structures of the angle. It is covered with endothelium and, when pigmented, iris processes can occasionally be seen clinically and can even be confused with peripheral anterior synechiae. This lacy tissue can be differentiated from peripheral anterior synechiae by the more solid appearing tissue and radial blood vessels in the iris tissue comprising synechiae. In cases of blunt trauma, the uveal meshwork/iris processes may be visibly torn.

Iris Processes. Iris processes are pigmented strands continuous with and histologically identical to the iris. These are a normal variant and have no effect upon aqueous outflow. They usually bridge the angle, arising from the peripheral iris to insert on the ciliary body or scleral spur, but can occasionally insert as high in the angle as the trabecular meshwork or Schwalbe's line. When fine and pigmented, iris processes can occasionally be confused with twigs of neovascularization. Also, their broken stumps are an occasional finding in cases of blunt trauma.

Ciliary Body Band. The ciliary body band is located immediately posterior to the scleral spur. The width of ciliary body that is visible depends upon how far posteriorly the iris inserts. The visible width of the ciliary body band increases in cases of blunt trauma with angle recession. In subtle cases it may be useful to perform simultaneous bilateral Koeppe gonioscopy to compare the two eyes.

The color of the ciliary body band is typically gray in darkly pigmented races or varying degrees of brown in lightly pigmented races. Abnormally dark ciliary body pigmentation, especially if asymmetric compared to the fellow eye, may be seen in cases of malignant melanoma. Abnormally light pigmentation, a cobwebby appearance, or even visualization of the underlying white sclera may be seen when the ciliary muscle has been torn in cases of blunt trauma. In traumatic or surgical cyclodialyses, a bottomless tunnel appears between the ciliary muscle and sclera. These are usually easily seen, but occasionally indentation gonioscopy is needed to bring a subtle cleft into view in a puzzling case of hypotony. If a cyclodialysis cleft is closed and not functioning, its bottom can occasionally be seen gonioscopically.

Online Subscriber Video: Angle Recession

Blood Vessels in the Angle. Normal circumferential vessels are found at the base of the iris or in the angle recess. These can occasionally have the appearance of an undulating "sea serpent" with segments of blood vessel visible against the ciliary body, punctuated by areas where the vessel dips posteriorly and out of view (see Figure 9). These normal vessels are never

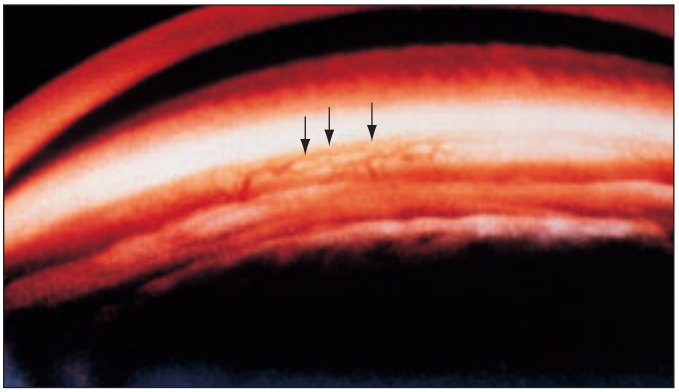

Figure 12. Angle neovascularization (arrows) in an eye with proliferative diabetic retinopathy.

seen attached to the angle anterior to the scleral spur. The other kind of normal vessels seen in the angle are the radial iris vessels within the iris stroma that may, in many cases, mimic corkscrews. On the other hand, vessels that take an erratic course and/or extend anteriorly past the level of the scleral spur along the wall of the angle are nearly always abnormal (Figure 12). Such neovascularization is invariably associated with vascular retinal abnormalities such as diabetic retinopathy, retinal venous or arterial occlusions, and ocular ischemic syndrome. They are usually accompanied by the relentless progression of peripheral anterior synechiae. Neovascularization in the angle is also seen in cases of heterochromic cyclitis, but the vessels are fewer, finer and not accompanied by peripheral anterior synechiae. Finally, abnormal vessels in the angle can be encountered in a healed cataract incision. Although this is an infrequent problem it should be kept in mind as a possible etiology of unexplained spontaneous hyphema in an aphakic or a pseudophakic eye.

Online Subscriber Video: Neovascularization of the Angle

Inflammatory Deposits in the Angle. Inflammation in the anterior segment from iridocyclitis or infection is recognized by the presence cells and flare and occasionally a hypopyon. When inflammation is only seen at the slit lamp as cells and flare in the anterior chamber, examination by gonioscopy may reveal inflammatory precipitates or peripheral anterior synechiae in the angle, usually inferiorly. Inflammatory glaucoma can present with a low-grade anterior chamber reaction and keratatic precipitates, discrete collections of inflammatory cells, on the trabecular meshwork. These gelatinous collections of inflammatory cells can be very subtle and difficult to recognize but are important to seek, especially in a puzzling case of unilateral open angle glaucoma.

Peripheral Anterior Synechiae. Peripheral anterior synechiae are abnormal adhesions between the peripheral iris and the forward structures in the angle. These adhesions often end at Schwalbe's line, but may extend onto the peripheral corneal endothelium in the iridocorneal endothelial (ICE) syndromes. Because they can arise as a consequence of a variety of ocular diseases and they adversely influence aqueous outflow, peripheral anterior synechiae are important findings and help diagnose the type of glaucoma present. They are never found in primary open angle glaucoma except in patients who develop peripheral anterior synechiae following laser trabeculoplasty. The most common causes of these adhesions are anterior segment inflammation, primary angle closure, plateau iris, neovascular glaucoma, flat anterior chamber following intraocular surgery, aphakic or pseudophakic pupillary block, and the ICE syndromes.

Conclusion

Gonioscopy should be performed on *all* patients with glaucoma, on *all* individuals suspected of having glaucoma, and on *all* individuals suspected of having narrow angles. Without gonioscopy, identification of the underlying mechanism and, therefore, the appropriate treatment of *any* glaucomatous condition is impossible. Gonioscopy is also required to perform various procedures for the treatment of glaucoma such as laser trabeculoplasty, peripheral laser gonioplasty, goniophotocoagulation, goniotomy, goniosynechialysis and internal revision of glaucoma filtration operations. Finally, in addition to diagnosis and treatment of glaucoma, gonioscopy is often necessary in the diagnosis and management of ocular trauma, intraocular foreign bodies, and complications of intraocular surgery.

James A. Savage, MD, is a practicing ophthalmologist, Southeastern Eye Center, Greensboro, North Carolina.

Wallace L. M. Alward, MD, contributed the video segments for this module. Dr. Alward is a professor, director of glaucoma service, and vice-chair of the Department of Ophthalmology and Visual Services, University of Iowa Hospitals and Clinics, in Iowa City, Iowa.

Clinicians' Corner

Clinicians' Corner provides additional viewpoints on the subject covered in this issue of Focal Points. *Consultants have been invited by the Editorial Review Board to respond to questions posed by the Academy's Practicing Ophthalmologists Advisory Committee for Education. While the advisory committee reviews the modules, consultants respond without reading the module or one another's responses.*—Ed.

1. In eyes where compression gonioscopy notes areas of appositional angle closure, if laser iridotomy is performed, how do you determine the presence of plateau iris? How common is plateau iris and how often do you perform gonioscopy in a patient with this syndrome?

Dr. Haynes: Indentation gonioscopy in plateau iris syndrome shows the deepest point of depression of the iris surface to be approximately two-thirds of the distance between the center of the iris and the periphery. The peripheral iris is being held forward by the ciliary body while the central iris is pushed back during indentation. This gives the appearance of a "lump" under the far peripheral iris during indentation.

Plateau iris syndrome can be diagnosed only when the angle has the typical plateau configuration and appears to be occludable despite the presence of a patent peripheral iridotomy. Plateau iris configuration refers simply to the gonioscopic appearance of a prominent peripheral roll of iris causing narrowing of the angle. Plateau iris syndrome is very rare. Plateau iris configuration is more common but both are uncommon compared to narrow angles due to relative pupillary block. In patients with plateau iris and a patent iridotomy, I perform gonioscopy on a regular basis. The exact frequency depends on how narrow the angle remains after iridotomy but should be at least every 6–12 months.

Dr. Reed: Often plateau iris is not detected until after a laser iridotomy is unsuccessful in deepening the peripheral angle. Clinically there is a difference as the iris plane is often flat instead of bowing forward as is seen with pupillary block. There is a deep central anterior chamber with a shallow peripheral angle due to a sharp, angled turn taken by the iris near its insertion. The condition is relatively rare. Gonioscopic examination of patients who have been diagnosed with a plateau configuration, but no secondary glaucoma, should be performed every 6 months. If glaucoma develops, a peripheral iridotomy should still be performed to relieve any pupillary block component and peripheral gonioplasty should be considered. The diagnosis of plateau iris and the possible risk of angle closure is very well visualized by ultrasound biomicroscopy.

2. In patients with uveitis and secondary open-angle glaucoma, how often do you perform gonioscopy to determine angle-closure contribution? Should laser iridotomy be performed in these eyes if there is no evidence of posterior synechia?

Dr. Haynes: The frequency of gonioscopic examination in these patients depends on how active the iritis has been but should be at least every 12 months. Laser iridotomy in patients with iritis should be performed only if there are significant posterior synechiae such that a secluded pupil might occur, leading to pupillary block.

Dr. Reed: On initial examination of a patient with uveitis and glaucoma, gonioscopic evaluation is important to determine whether areas of peripheral anterior synechiae (PAS) are present. Repeat gonioscopy on these patients should be performed after every flare-up of their uveitis to rule out additional PAS formation. If intraocular pressure rises, I will repeat gonioscopy to help determine if the pressure problem is due to progressive synechial angle closure. With no evidence of posterior synechia, there would be no pupillary block and so no reason to perform a laser iridotomy. An iridotomy would not improve the peripheral angle anatomy and could be contraindicated as potentially it could increase inflammation.

3. In a pseudophakic eye with a sulcus-fixated posterior chamber lens and areas of angle closure,

how often do you perform gonioscopy if secondary angle-closure glaucoma is noted?

Dr. Haynes: When the synechiae are first noted in this condition, I would suggest repeating the gonioscopy every 3 months. If the synechiae have been present for a year or more without change, the frequency could be decreased to every 6–12 months.

Dr. Reed: I will perform gonioscopy on initial exam to confirm the diagnosis of secondary angle-closure glaucoma. If there is no additional recurrent uveitis or other problems, I rarely repeat it.

4. In eyes with suspected "creeping" chronic angle closure due to enlargement of the nuclear sclerotic cataract and in the presence of a patent laser iridotomy, how often would you perform gonioscopy? When is goniophotocoagulation-iridoplasty performed and what laser settings do you recommend?

Dr. Haynes: Gonioscopy should be performed at each visit, typically every 3–6 months. Goniophotocoagulation-iridoplasty should be performed if there is evidence of progressive angle compromise and cataract extraction is not indicated. Long, slow burns are best for iridoplasty. I use a 200–500 μm spot size and duration of 0.2–0.5 seconds, and I titrate the power until I note visible shrinkage of the iris. This typically results in power settings of 150–400 mW.

Dr. Reed: I would perform gonioscopy on each of the patient's regular follow up visits, every 4–6 months. Compression gonioscopy is useful to determine if there is synechial closure or just iris apposition. If synechial closure is developing, I would recommend cataract surgery as the definitive means of deepening the peripheral angle. Goniophotocoagulation-iridoplasty can help to widen the angle but I find it more useful in the plateau iris configuration than in the progressively increasing convex iris configuration seen in an angle with a developing cataract. When performing gonioplasty, I use the argon laser at a setting of 200 mW, 200 μm spot size, and duration of 0.2 second. I use the gonioscopic mirror of a Goldmann three-mirror lens and aim for the peripheral iris roll. The goal is to see shrinkage of the iris and a deepening of the angle. If a large portion of the angle is to be treated, the spot size can be increased to 500 μm and the duration increased to 0.5 second and the laser beam applied directly on the peripheral iris through the center of the Goldmann lens.

5. What is your preferred method of recording gonioscopic findings? Do you record different locations of findings?

Dr. Haynes: I use a modified Shaffer system and grade the angle from 0–IV with IV being wide open and 0 being closed. A drawing is made dividing the angle into superior, temporal, inferior, and nasal quadrants in order to record findings.

Dr. Reed: Several excellent classification systems have been proposed. Several excellent classification systems have been proposed. Scheie described one system for grading the narrowing of an angle on a scale of I to IV, with I describing an angle where ciliary body band but no iris root is visible progressing to IV where no angle structures are seen. The system that I see most commonly used is Shaffer's classification system which describes the opposite. A grade 0 angle is closed, a grade I is open to approximately 10 degrees, II open to 20 degrees, III open to 30 degrees, and IV open to 40 degrees or more. Spaeth developed a classification system that expands on Shaffer's to include the site of the iris insertion and the shape of the peripheral iris. The iris insertion is specified using A if the insertion is anterior to the trabecular meshwork, B if the insertion is behind Schwalbe's line, C if the insertion is at the scleral spur, D if the angle is deep with a visible ciliary body band, and E if the angle is extremely deep. The peripheral iris is classified as *q* if it is a concave configuration, *r* if it is a regular straight iris, and *s* if the peripheral iris configuration is convex.

Clinically, I find the most useful system is to describe the anatomy that I see. I record the most posterior structure that is visible in each of the four quadrants and make a note of any unusual peripheral iris configuration, as well as the degree of pigmentation.

6. In eyes with suspected neovascular glaucoma, what is your preferred method of gonioscopy? How often do you perform gonioscopy in eyes with pro-

liferative diabetic retinopathy or in eyes with prior central retinal vein occlusion (CRVO)?

Dr. Haynes: I most often use a Zeiss four-mirror lens because I keep this lens readily available and it does not require special gonioscopic liquid. However, a Goldmann three-mirror lens sometimes provides a superior view of the angle. In patients with proliferative diabetic retinopathy, I perform gonioscopy every 6–12 months or more often in the presence of iris vessels at the pupillary margin and/or flare in the anterior chamber. In eyes with a CRVO, I perform gonioscopy at each visit (at least monthly) within the first 3–4 months and then every 6–12 months thereafter. If vessels are noted at the pupillary margin and/or flare is noted in the anterior chamber, the frequency of gonioscopic examination may need to be increased.

Dr. Reed: I prefer to use the Zeiss four-mirror lens for most gonioscopy. Diabetic patients should be examined undilated for pupillary rubeosis as well as angle neovascularization frequently present in newly diagnosed proliferative diabetic retinopathy. Particularly if the fluorescein angiogram has shown ischemia with capillary nonperfusion, gonioscopic exams should take place every few weeks while the panretinal photocoagulation is being performed.

With central retinal vein occlusions, gonioscopy should also be performed frequently at first. Classically, neovascular glaucoma occurs an average of 90 days following a vein occlusion. Clinically, it can occur anytime within a few weeks to 6 months following the event and, again, is much for common in the presence of retinal ischemia. I will perform gonioscopy on these eyes every 4 weeks.

7. What is the accepted technique for sterilization of gonio prisms between uses? What is the current standard of care?

Dr. Haynes: In 1988, the American Academy of Ophthalmology, the Contact Lens Association of Ophthalmologists, and the National Society to Prevent Blindness jointly issued guidelines for disinfecting lenses. The guidelines suggest wiping the inner surface of the contact lens with an alcohol sponge. This is the current standard of care. For added protection, one could invert the lens and fill it with a 1:10 solution of household bleach, leaving the solution for 5 minutes and then rinsing with water.

Dr. Reed: In the office or clinic setting, swabbing a gonio prism with alcohol is the general standard of care. The lenses also can be soaked in a 10% bleach solution for 25 minutes according to the company insert. The Academy states that swabbing with alcohol is sufficient [*Minimizing Transmission of Bloodborne Pathogens and Surface Infectious Agents in Ophthalmic Offices and Operating Rooms*. Information Statement. Revised 2004].

For sterilization of the lenses during surgical procedures, a soak in a Cidex solution for 10 minutes is acceptable. Our hospital has recently switched to using the Steris System (STERIS Corp., Mentor, Ohio), which uses a chemical sterilization with peracetic acid, Steris 20 Sterilant concentrate. These lenses are not autoclavable.

8. In eyes with suspected pigment dispersion syndrome, are there changes in angle pigmentation over time? How often should gonioscopy be performed? What is the best way to record findings?

Dr. Haynes: In patients with the pigment dispersion syndrome, the angle can become more or less pigmented with time. Gonioscopy in these patients should be performed yearly, noting the amount of pigmentation in each quadrant. For these cases I use Scheie's system of documenting angle pigmentation where angle pigment is graded 0–IV, with 0 being no pigmentation and IV being heavy pigmentation.

Dr. Reed: The angle in pigmentary dispersion syndrome typically shows a dense, homogeneous band of dark brown pigment extending throughout the entire circumference of the trabecular meshwork. Because there is such a dense, homogeneous band, any increase in pigmentation may be too subtle to detect clinically. On the other hand, an increase in the number of transillumination defects can often be seen, and so one can infer that there is most likely some increase in pigmentation with time.

Typically, I perform gonioscopy on the initial exam and make a note of the degree of pigmentation, which is usually 4+ for 360°. I also make note

of the iris configuration, which is often the classic concave appearance.

9. In eyes with exfoliation syndrome (also called *pseudoexfoliation)* and suspected asymmetric shallowing of anterior chamber noted by the Van Herick method, how frequently would you recommend gonioscopy to determine potential angle closure?

Dr. Haynes: Because loose zonules can allow forward movement of the lens in this condition over time, thus leading to angle closure, I would suggest performing gonioscopy at each visit, typically every 3–4 months. I would have a low threshold for performing a laser peripheral iridotomy in patients with forward movement of the lens due to loose zonules.

Dr. Reed: Angle closure is rare but has been reported several times as an etiology of glaucoma in pseudoexfoliation. Presumably, the degenerative changes in the zonular fibers, which cause the often-seen phacodonesis, can even result in the forward subluxation of the lens itself. If asymmetric shallowing of the anterior chamber is present, I would perform gonioscopy on every regular follow-up visit (every 4–6 months).

William L. Haynes, MD, is assistant consulting professor of ophthalmology, Duke University, Durham, North Carolina, and a practicing ophthalmologist with Asheville Eye Associates, Asheville, North Carolina.

Janis English Reed, MD, is a glaucoma specialist in private practice in West Virginia and Ohio.

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