ocular pressure (Fig. 20). This change is slow and rather infrequent, but indicates that certain defects are reversible.

The majority of visual field defects unfortunately remain either unchanged or show progression. The progression is often related to poor medical or surgical intraocular pressure control. Other factors apart from the pressure level must be considered.

Progression of a visual field defect is probably the most important indication for more intensive medical or surgical therapy. Therefore, progression must be properly evaluated. In many glaucoma patients, changes in the contour of the isopter are due to progressive lens opacities, which also result in reduction of visual acuity. Changes of the isopter may therefore be a misleading sign of progression of glaucomatous damage. They may be merely due to miotic pupils or developing opacities of the media. Static, profile perimetry is well suited to an analysis of visual field progression. Careful quantitative kinetic perimetry can be used for the same purpose.

Changes in medication which alter the refraction or pupillary diameter must not be disregarded, and visual fields should be replotted so that new base lines are established. Progression should then be measured from the new base line fields.

I am indebted to Mrs. M. Fairclough, Miss J. Bryett, and Miss C. Wheeler for the excellence of the visual fields.

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Interpretive gonioscopy in glaucoma

H. Dunbar Hoskins, Jr.

Gonioscopy is necessary for determining the mechanisms causing increased intraocular pressure in the patient with glaucoma. There are useful methods which simplify the gonioscopist's task. Particular emphasis is placed upon positioning the lens, pressure gonioscopy, and special illumination techniques as they apply to the glaucoma patient.

Key words: glaucoma, gonioscopy, intraocular pressure, lens positioning, illumination techniques

Since Uribe Troncoso1 developed the first gonioscope, ophthalmologists have been interested in the detailed study of the iridocorneal angle. Development of techniques and innovations have since im-
proved our ability to evaluate the angle structures. The purpose of this paper is to discuss some of these methods in light of their application to the evaluation of the glaucoma patient.

Gonioscopy is an examination technique familiar to all ophthalmologists. Unfortunately it is not always used to its fullest advantage. The reasons for this range from difficulty in identifying the angle structures to inconvenience and cumbersoness of the procedure. Although it is only by repeated use that an examiner can become familiar with the gonioscopic appearance of the angle, some of the troublesome aspects can be relieved by a knowledge of a few of the more subtle gonioscopic maneuvers which are less well known.

Since the introduction of the indirect goniolens (Goldmann), there has been continuing controversy over which of the two techniques (direct versus indirect) is superior. Advocates of each have cited advantages for their preferred method. Suffice it to say that, regardless of the technique preferred, experienced observers will agree on the diagnostic and therapeutic evaluation of a given angle. It is the author's opinion, however, that indirect (Koeppe) gonioscopy has advantages for the inexperienced gonioscopist. It provides a more comfortable position for both the examiner and the patient and allows a more relaxed investigation of the entire angle circumference. It does require additional instrumentation in the form of a counterbalanced gonioscope and hand-held illuminator, but the maneuverability of both the examiner and the light source gives additional advantages to the indirect technique. The lack of necessity for manipulating the Koeppe lens after its insertion also simplifies the examiner's task and allows rapid comparison of the two eyes by inserting two lenses simultaneously.

Errors in gonioscopy most frequently result from misinterpretation of the positions of the angle structures visualized. The anatomy of this area and routine gonioscopic appearance of the angle has been adequately described elsewhere and will not be discussed.

Although gonioscopy certainly has other uses, in glaucoma its primary application lies in distinguishing between an open angle and one that is closed or occluded. This is essential in choosing the proper therapeutic course. Therefore the single most important angle structure to be identified is the functioning portion of the trabeculum overlying Schlemm's canal. If this area is seen to be unobstructed throughout the majority of the angle circumference, then an elevated pressure at that time must be at least partially due to open-angle glaucoma and a simple iridectomy will not be curative.

In the wide open angle with normal structures, this area is easily recognized by one familiar with the anatomy. In the eye with a narrow angle configuration or with changes such as abnormal pigmentation, inflammatory debris, prominent iris processes, peripheral anterior synechiae, or vascular anomalies, the problem is more difficult. There are some clues which are helpful.

**Positioning of the lens**

It is necessary to have the angle of observation high enough so the line of sight (A) does not reach the depths of the angle. The lens must be rotated toward the angle (B).

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Fig. 1. With goniolens centered on cornea, the line of sight (B) does not reach the depths of the angle. The lens must be rotated toward the angle (A).
sight passes over the last roll of the iris into the depths of the angle. This is done with indirect gonioscopy by rotating the mirrored lens toward that part of the angle being examined (Fig. 1).

With indirect gonioscopy, observation of the slit beams can help in locating the extreme depth of the angle. If the narrowed slit beam directed from a point lateral to the observer's line of sight crosses the iris and joins perfectly with the one coming down from the cornea, then the irido-corneal junction is being viewed. If these lines fail to meet (Fig. 2), then the optimum angle of observation has not been achieved and the lens must be rotated further toward the angle.

With direct (Koepppe) gonioscopy, the examiner simply adjusts the angle of observation with the more maneuverable gonioscope until the deepest portion of the angle is seen (Fig. 3).

**Blood in Schlemm's canal**

This should always be sought because it immediately localizes the filtering portion of the trabeculum. Unfortunately it usually is not present in glaucoma. Often it can be produced by jugular compression or with a modified Koepppe lens adapted for suction. The flange of the lens then blocks venous outflow and causes regurgitation of blood into the canal which is seen as a pinkish band above the scleral spur.
Fig. 4. The light directed from point A strikes the cornea anterior to the angle and is internally reflected within the cornea and sclera. The pigment in the trabecular meshwork and ciliary body prevents the light from entering the angle. The scleral spur (B) lights up brightly.

Pigment

In the child or young adult, it is unusual to have the angle structures delineated by pigmented deposits. With increasing age, loose pigment in the anterior chamber is deposited in two major areas in the angle. Inferiorly it collects, rather diffusely, around Schwalbe’s line. The change from corneal to scleral curvature at this point creates a shelf which holds the pigment granules that settle there due to gravity. The second area is in the actively filtering portion of the trabeculum overlying Schlemm’s canal. As the aqueous passes through the meshwork, the pigment is filtered out and forms a nicely demarcated light brown to black band bordered posteriorly by the white line of the scleral spur. This pigment band is one of the most valuable aids in gonioscopy, since it accurately outlines the functioning portion of the trabecular meshwork. If the pigment band is very dense, then pigmentary glaucoma or pseudoexfoliation of the lens capsule should be suspected.

Scleral spur

The scleral spur is seen gonioscopically as a white line lying between the anterior extension of the ciliary body and the posterior or filtering portion of the trabeculum. In heavily pigmented or narrow-angle eyes, it is often difficult to identify. Gonioscopy with the Koeppe lens allows a maneuver most helpful in locating this important structure. If the Barkan illuminator is directed so the light beam strikes the cornea anterior to the angle, the light is internally reflected within the sclera. The spur is then illuminated from within the sclera by scleral scatter (Fig. 4) and stands out as a brighter line in the relatively darker angle. This is especially useful in eyes with narrow angles. When the iris approaches the angle wall at the level of the scleral spur, direct illumination reveals the pigmented portion of the trabeculum projecting just anterior to the point of iridocorneal apposition. The examiner is often unsure how much of the functioning trabeculum is exposed. The technique of indirect illumi-
nation highlights the scleral spur and makes it visible when it could not be seen with routine methods. If the spur is highlighted, then that portion of the angle is open for the drainage of aqueous.

Recognizing iris processes, whose significance has recently come under investigation,\(^4\)\(^5\) is also simplified by this method of indirect illumination. In lightly pigmented eyes, processes extending from the iris to the trabecular surface may be difficult if not possible to see by direct illumination. Indirect illumination makes them visible as darker lines crossing the highlighted angle.

This procedure is more difficult with indirect gonioscopy but can be performed with certain slit lamps. The light beam must be parallel to Schwalbe's line and decentered so that it strikes the cornea anterior to the angle. The effect, although useful, is not as impressive as that with the Koepp method.

**Pressure from lens**

With either direct or indirect gonioscopy, it is important not to artificially narrow or open the angle with pressure from the examining lens. In a soft or normotensive eye, pressure from the edge of the lens at or slightly anterior to the limbus can indent the cornea and create a change in curvature within the angle which closely mimics the change in curvature seen at Schwalbe's line (Fig. 5). This gives the appearance of a much narrower angle than actually exists. Rotation of the lens away from this position allows the angle to open to its true width.

Similarly, in a normotensive eye pressure from the lens over the center of the cornea or the opposite angle can displace aqueous into the portion of the angle being observed. This retrodisplaces the iris and gives a false impression of a wider angle.

**Pressure gonioscopy**

A lens that has recently been popularized is the Zeiss four-mirror gonioprism with the Unger handle. Its corneal surface has a curvature slightly flatter than the front surface of the cornea and can be applied directly to the cornea without any intermediary solutions. It is helpful to stabilize the instrument by bracing one's hand against either a portion of the slit lamp headrest or the patient's cheek. Although inadvertent introduction of air bubbles is initially troublesome, a little practice smooths the technique.

By exerting pressure on the cornea with the prism, aqueous is forced into the angle and widens it.\(^6\) The iris is pushed backward and conforms to the shape of the lens. By this means, narrow angles can be opened to differentiate between true synechia and simple apposition of iris to cornea. If only apposition exists, the angle will open to reveal the deeper structures. If the iris appears to rise up from the lens periphery to insert in a broad stump high on the angle wall, then synechie are likely present. This is confirmed if a directly adjacent portion of the angle is seen to open. Sometimes aqueous trapped behind the iris prevents its falling back. This can lead to an overestimation of synechia formation, and the maneuver should be repeated with firmer pressure if one is in doubt. If the intraocular pressure is ele-
vated much above 35 mm. Hg, it may be impossible to retrodisplace the iris enough to expose the angle. Therefore, in acute angle closure glaucoma it is best to delay the maneuver until the pressure has been lowered medically.

This method is also valuable in evaluating synechia formation in patients suspected of having chronic angle closure glaucoma. In both acute and chronic angle closure glaucoma, assessment of the extent of synechial closure of the angle aids in deciding whether filtration surgery or simple peripheral iridectomy is indicated. When performing routine gonioscopy with this or a similar lens, its ability to open the angle must be remembered and undue pressure on the cornea should be avoided. The lens should rest lightly against the cornea so that any less pressure would allow entrance of an air bubble.

A Koepp goniolens has an additional advantage not concerned with observation of the iridocorneal angle. In patients with miotic pupils or cloudy media, ophthalmoscopic evaluation of the disc can be difficult if not impossible. A smooth domed Koepp lens (without a dimple) is a great aid in seeing the disc in such patients. With the lens in place on the eye, any corneal irregularity is eliminated and the fundus is minified so that the disc usually can be seen through even the smallest pupil. A well-aligned ophthalmoscope with bright light and small (macula) aperture is necessary. This technique is also useful for obtaining an undistorted view through a peripheral iridectomy when miosis or posterior synechiae combined with central lens opacities preclude seeing through the pupil.

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Functional status of the glaucoma patient

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Key words: glaucoma, intraocular pressure, optic disc evaluation, visual field examination

A large amount of information can be accumulated on every glaucoma patient.

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This can be of great value to the clinician if it is appropriately organized and meaningful priorities are established. If priority of data is not established or if the physician fails to organize the data, considerable confusion can arise leading to errors in judgment and creating difficul-