

## 17 Ophthalmic Instruments and Diagnostic Tests

*Samuel Boyd and Amar Agarwal*

### ◆ Cover Testing

#### Cover/Uncover Tests

##### ◆ Cover Test

The cover test is done to confirm the presence of a manifest squint. The patient is asked to look at the fixation target (a flashlight should never be used as a fixation target because it fails to control accommodation—an accommodative fixation target held at 33 cm is used for near and the Snellen 6/9 visual acuity symbol is used for distance fixation). The apparently fixating eye is then covered and the behavior of the uncovered eye is noted. Each eye is tested in turn for near (33 cm) and distance (6 m). It is performed in all nine positions of gaze. Head posture should be straight. The test is performed with and without eyeglasses. In the presence of squint, the uncovered eye moves to take up fixation. If there is no movement of the uncovered eye, that eye is then covered and the other eye observed. No movement of either eye is seen in pseudosquint.

##### ◆ Uncover Test

Cover the apparently fixing eye and observe the other eye (apparently deviating eye). If movement is seen, then there is heterotopia.

##### ◆ Cover/Uncover Test

This test tells about the presence and type of heterophoria. The patient looks at the fixation target and one eye is covered with an occluder. The occluder is then removed, and the eye under cover is observed. The findings vary depending on the diagnosis:

- ◆ In a person with normal vision, covering either eye will not produce any movement of the other eye. On removing the occluder, there is no movement of the uncovered eye, which continues to look straight ahead.
- ◆ In heterophoria, the eye under cover will deviate in the direction of the heterophoric position. On uncovering, it will move in the opposite direction to reestablish binocular fixation. The opposite eye continues to maintain fixation and makes no movement. Thus only one eye moves in case of a heterophoria.
- ◆ In heterotropia, on covering the fixating eye, the opposite eye, provided it is able to do so, will make a movement from the heterotropic position to take up fixation, and the covered eye will make a corresponding movement in accordance with the Hering law. On uncovering the formerly fixating eye, it will either move again to take up fixation or may continue to remain deviated de-

pending on whether it is a unilateral or an alternate heterotropia. One can also make out the fixation pattern, that is, whether there is strong fixation preference for one eye, free alternation (formerly deviated eye continues to maintain fixation indefinitely), weak alternation (formerly deviated eye maintains fixation for some time, such as until a blink), or eccentric fixation (on covering the fixating eye, the deviated eye makes no movement or an incomplete movement) is present.

### Prism Bar Cover Test

This is an objective method of measuring the deviations. Apply the following rule: the apex of the prism should point toward the deviation:

- ◆ *Esodeviations*: Place the prism base out.
- ◆ *Exodeviations*: Place the prism base in.
- ◆ *Right hypertropia*: Place the prism base down in front of the right eye.
- ◆ *Right hypotropia*: Place the prism base up in front of the right eye.
- ◆ *Combination of vertical and horizontal deviation*: Place horizontal prisms in front of one eye and vertical prisms in front of the other eye.

### Alternate Cover Test

In this test, the patient looks at the fixation target with both eyes open, and the occluder is alternately moved between the two eyes to produce maximal dissociation of the two eyes. This prevents fusion between the two eyes and decompensates any latent squint. The patient should not be allowed to regain fusion while the cover is being transferred. It can be used to diagnose a latent squint of even 2 degrees and small degrees of heterotropia. It also differentiates concomitant squint from paralytic squint.

## ◆ Rod Tests

### Maddox Rod Test

The patient is asked to fix on a point light in the center of the Maddox tangent scale at a distance of 6 m. A red Maddox rod (which consists of many glass rods of red color set together in a metallic disk) is placed in front of one eye with the axis of the rod at a right angle to the axis of deviation. The Maddox rod converts the point light image into a line. Thus the patient will see a point light with one eye and a red line with the other. Due to dissimilar images of the two eyes, fusion is broken and heterophoria becomes manifest. The number on the Maddox tangent scale where the red line falls will be the amount of heterophoria in degrees (**Fig. 17.1**).

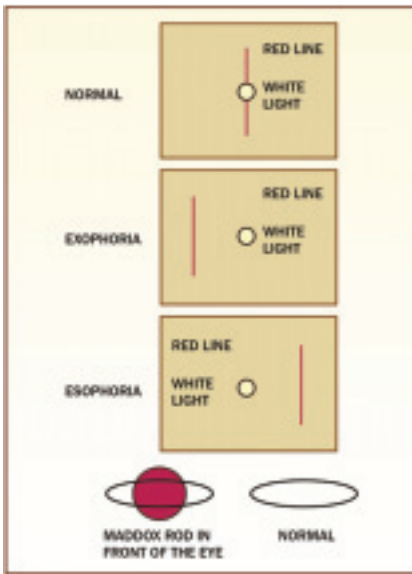


Fig. 17.1 Maddox rod test.

### Double Maddox Rod Test

This test helps in detecting and measuring cyclodeviations. Place a red Maddox rod vertically in front of the patient's right eye and a white Maddox rod also vertically in front of the other eye in a trial frame. The axes of the Maddox rod(s) are rotated until the two lines seen by the patient are parallel. The degrees of cyclodeviation and direction are measured from the trial frame with exocyclodeviation having outward rotation and incyclodeviations having inward rotations.

### Maddox Wing Test

The Maddox wing is an instrument by which the amount of heterophoria for near (at a distance of 33 cm) can be measured. It is based on the principle of dissociation of fusion by dissimilar objects. It has two slit holes in the eyepiece. The fields that are exposed to each eye are separated by a diaphragm in such a way that they glide tangentially into each other. The right eye sees a white arrow pointing vertically upward and a red arrow pointing horizontally to the left. The left eye sees a horizontal row of figures in white and a vertical row in red. These are calibrated in diopters of deviation. The arrow pointing to the horizontal row of figures and the arrow pointing to the vertical row are both at zero in the absence of a squint or in the presence of squint with a harmonious abnormal retinal correspondence.

Clinically important points are as follows:

- ◆ The Maddox wing should be held pointing 15 degrees inferiorly, as for reading.
- ◆ It is important to do the test with and without correction for refractive errors.
- ◆ The ability of the patient to give an answer on the Maddox wing does not mean the patient has normal binocular vision because the patient can have abnormal retinal correspondence (ARC) or rapid alteration.

## ◆ Stereopsis and Fusional Testing

### ◆ Stereopsis

Stereopsis is the visual appreciation of three dimensions during binocular vision. It is a function of spatial disparity and arises when horizontally disparate retinal elements are stimulated simultaneously. The fusion of these disparate retinal images will result in a single visual impression perceived in depth, provided the fused image lies within the Panum area of binocular single vision.

### ◆ Tests for Stereopsis

#### *Titmus Test*

The titmus test consists of a three-dimensional Polaroid vectograph—two plates in the form of a booklet, which has to be viewed through Polaroid spectacles. On the right there is a large fly and on the left a series of circles and animals. The working distance is 16 inches (40 cm).

#### *Fly Test*

The fly test is for gross stereopsis (degree of disparity is 3000 seconds of arc). The fly should appear solid and the subject should be able to pick up one of the wings of the fly. On inverting the book, the targets will appear to recede. If the fly appears as a flat photograph, the subject is not appreciating stereoscopic vision.

#### *Circles Test*

The circles test measures fine stereopsis (degree of disparity is 800 to 40 seconds of arc). There are nine squares, each of which contains four circles. One of the circles in each square will appear forward of the plane of reference in the presence of normal stereopsis. The subject that perceives the circle to be shifted off to the side is not appreciating stereoscopic vision but is using monocular clues instead.

#### *TNO Test (degree of disparity is 480 to 15 seconds of arc)*

The TNO test consists of seven plates to be viewed with red-green spectacles. Each plate has various shapes created by random dots in complementary colors. Some shapes are visible without glasses, whereas others can be appreciated in the presence of stereopsis only. It has no monocular clues.

#### *Lang Test (degree of disparity is 1200 to 600 seconds of arc)*

The targets are seen alternately by each eye through the built-in cylindrical lens system; hence there is no need for special spectacles.

#### *Frisby Test (degree of disparity is 600 to 15 seconds of arc)*

There are three transparent plates of varying thickness. On the surface of each plate there are printed four squares of small random shapes. One of the squares contains a hidden circle in which the random shapes are printed on the reverse of the plate. The subject must identify this hidden circle.

### ◆ Base-Out Prism

This is a quick and simple method using a 20 diopter base-out prism to detect binocular single vision (BSV).

## ◆ Synoptophore

All types of heterophorias and heterotropias can be measured accurately with a synoptophore (both objective and subjective angle of squint). In the synoptophore the rays of light from the target hit a mirror and then pass through a convex lens of + 6.5 diopters to reach the eye. Thus the image is seen behind the mirror, for example, at a distance of 6 m, which will be equal to the focal length of the lens. Thus the synoptophore images are seen at a distance and not near. This is because we do not want the patient to use his or her accommodation. The technique for using the synoptophore is as follows (**Fig. 17.2**):

- ◆ Interpupillary distance (IPD) is checked and adjusted.
- ◆ Angle kappa is measured.
- ◆ Simultaneous macular perception is tested for.

We use the simultaneous paramacular perception slides. Both the objective and subjective angles of squint are checked in all nine cardinal positions of gaze (one is the primary position and the other eight are 15 degrees from the primary position).

To test the objective angle, one arm of the synoptophore is fixed at zero degrees. The other arm is moved until there is no movement of the eyes when the tester alternately switches on and off the lights of the two arms. The point where the eyes do not move is the objective angle.

To test the subjective angle, one arm of the synoptophore is fixed at zero degrees. The patient is shown slides of a lion and its cage. The slide of the cage is kept in the arm that is fixed. The patient is asked to move the other arm (containing the slide of the lion) so as to put the lion in the cage. The angle at which this is done is the subjective angle of squint.



**Fig. 17.2** Synoptophore

To detect abnormal retinal correspondence (ARC) with the synoptophore, the objective angle (OA) and the subjective angle (SA) of squint are first determined, which gives the angle of anomaly (AOA).

$$\text{AOA} = \text{OA} - \text{SA}$$

In the case of normal retinal correspondence (NRC), the SA is equal to the OA, and the AOA will be zero. In unharmonious ARC, the subjective angle will be less than the objective angle, and the difference between the two should be at least 5 degrees or more. In the case of harmonious ARC, the subjective angle will be zero. Thus the angle of anomaly in a harmonious ARC will be equal to the objective angle.

- ◆ *Fusion*: For testing fusion, two slides are used: one is that of a rabbit without a tail and the other is that of a rabbit without ears. The two slides are kept in each arm of the synoptophore and the arms are fixed at the angle of squint. If the patient sees both the ears and the tail, then fusion is present. If the patient sees either the tail or the ears, fusion is absent.
- ◆ *Stereopsis*: Stereopsis can be tested with slides containing paratroopers with a plane in the background. The patient should be able to tell whether the paratroopers are in front of the plane or not, which indicates good stereopsis.
- ◆ *After images*: After images can also be done.

## ◆ Visual-Field Testing

The visual field is the portion of space that is visible to the fixation eye. Visual-field examination is the examination of the function of the visual system in the field and not only the determination of the limits of the field. The difference threshold is the smallest measurable difference in luminance between a stimulus and the background (**Fig. 17.3**).

### *Automated Static Perimetry*

The different tests in autoperimetry are as follows:

- ◆ *Suprathreshold test*: This test is used as a screening device for severe or moderate defects.
- ◆ *Threshold related strategy*: The actual threshold is determined at a small number of points and they are used to extrapolate the hill of vision.
- ◆ *Threshold testing*: Threshold testing is the standard of care for glaucoma management. Many points are tested and there are different strategies used to accurately define the visual field. These tests can be long and the patients can become fatigued.
- ◆ *SITA*: Because full threshold can be time consuming, shorter algorithms have been developed. The Swedish Interactive Thresholding Algorithm (SITA) uses mathematical modeling and present understanding of the visual field to increase accuracy while speeding up the test.
- ◆ *Short-wavelength automated perimetry (SWAP)*: This selectively tests the short-wavelength pathway by presenting a blue target on a yellow background. SWAP may be able to show defects 1 to 3 years before standard techniques.

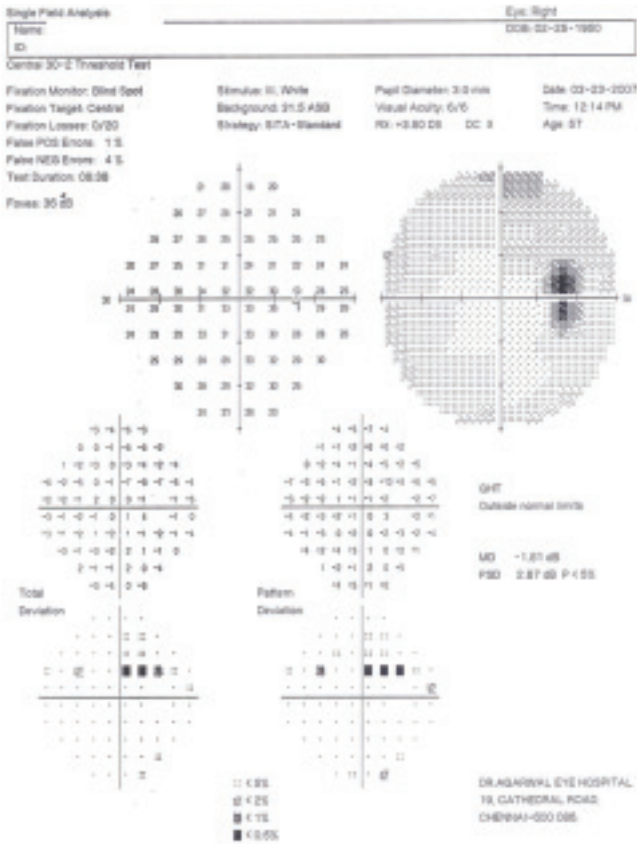
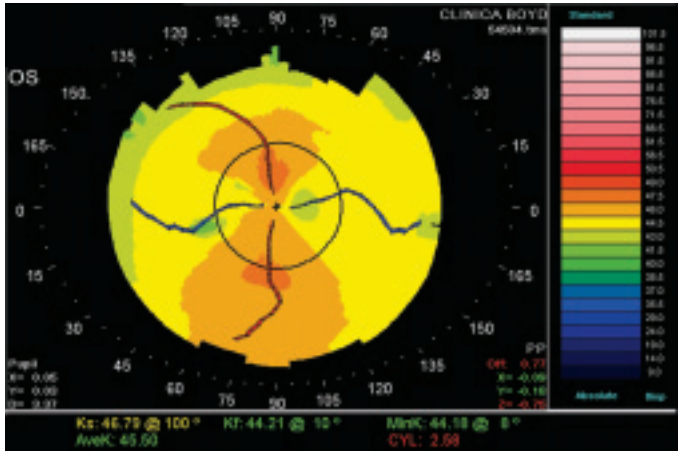


Fig. 17.3 Humphrey autoperimetric 30-2 test.

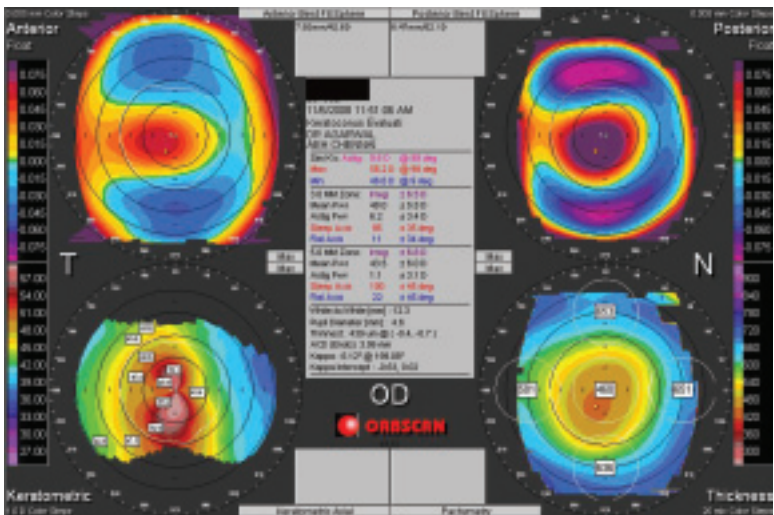
The various field defects seen in glaucoma are generalized depression, barring of the blind spot, isolated paracentral scotoma, Seidel scotoma, Bjerrum scotoma or arcuate scotoma, double arcuate scotoma, Ronne nasal step (which respects the horizontal midline), temporal wedge defect, peripheral breakthrough, altitudinal defect, central and temporal islands, and split fixation.

## ◆ Automated Corneal Topography

Imaging techniques of the cornea are developing rapidly, mainly because of continuous advances in refractive and cataract surgery. It is crucial to understand the significance of new imaging techniques and the relevant principles of corneal optics. The discussion of the most common clinical method of Placido-based corneal topography emphasizes important concepts of its clinical interpretation (**Fig. 17.4**).



A



B

**Fig. 17.4** (A) Astigmatic corneal topography. (B) Orbscan topography of an eye with keratoconus.



### *Optical Properties of the Cornea*

Several concepts are used to characterize optical properties of the cornea, such as curvature, shape, local surface, power, expressed as refraction in diopters, thickness, and three-dimensional structure. The keratometric value is a concept inherited from keratometry and is calculated simply from radii of curvature as follows:

$$K = \text{refractive index of } 337.5 / \text{radius of curvature}$$

The intact central corneal thickness of ~560  $\mu\text{m}$  is considered enough to ensure long-term mechanical stability of the cornea. The peripheral thickness (~600  $\mu\text{m}$ ) is certainly clinically important in some refractive procedures such as intracorneal rings, astigmatic keratotomy, and cataract surgery. With the advances in corneal imaging and widespread refractive surgeries, corneal behavior will likely be better understood. Corneal topography instruments used in clinical practice most often are based on Placido reflective image analysis. This method of imaging of the anterior corneal surface uses the analysis of reflected images of multiple concentric rings projected on the cornea.

### *Interpretation of Topographic Maps*

Every map has a color scale that assigns particular color to a certain keratometric dioptric range. Never base an interpretation on color alone. The value in keratometric diopter is crucial in the clinical interpretation of the map and has to be looked at with the interpretation of every map. Absolute maps have a preset color scale with the same dioptric steps and dioptric minimum and maximum assigned to the same colors for particular instrument.

Normalized maps have different color scales assigned to each map based on instrument software that identifies the actual minimal and maximal keratometric dioptric value of a particular cornea. The dioptric range assigned to each color is generally smaller compared with the absolute map, and, consequently, maps show more detailed description of the surface. The disadvantage is that the colors of two different maps cannot be compared directly and have to be interpreted based on the keratometric values of their different color scales.

## ◆ Specular Microscopy

This is an important part of the preoperative evaluation, especially if corneal guttata or other signs of a low endothelial cell count are found. It is clinically and medical-legally important to document a low endothelial cell count before LASIK, rather than worry later whether LASIK caused it. It must be done before any examination that might roughen or dry the corneal surface. Although endothelial cell changes following lamellar surgery (including LASIK) have not been reported clinically, they have been seen experimentally when excimer ablation of greater than 90% depth was achieved. This depth is of course entirely contraindicated in patients, but two cases of corneal perforation during LASIK have recently been reported, and one would assume that other cases with deep ablation must also exist (**Fig. 17.5**).

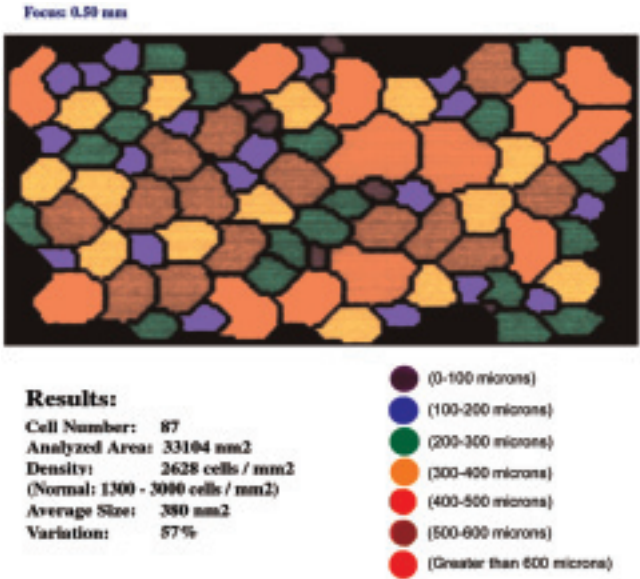


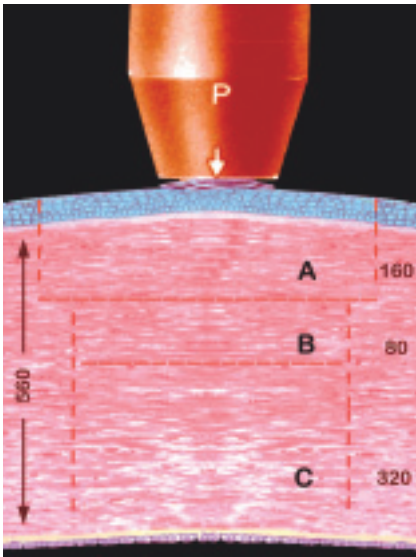
Fig. 17.5 A normal specular microscopy.

## ◆ Corneal Pachymetry

Study of the central cornea with ultrasound pachymetry is fundamental. The surface of the ultrasonic pachymeter probe is wiped with alcohol and does not need to be sterilized. This instrument is used to take a very careful and accurate reading of the thickness of the central cornea. The pachymeter probe is placed on the center of the cornea, perpendicularly, to determine corneal thickness. The pachymeter has a console displaying the corneal thickness reading (Fig. 17.6).

### *Clinical Importance*

Ideally, we must preserve a minimum of 250  $\mu\text{m}$  in the posterior stromal bed. Other investigators consider that preservation of a minimum of 50% of the preoperative central pachymetry is essential. This is referred to as the *Barraquer law of corneal thickness*. This is particularly important in the treatment of high refractive errors with the excimer laser and in “enhancement” procedures. Unless sufficient corneal stroma remains, as determined by Barraquer’s basic principle, there is an increased risk of developing corneal ectasia. It is generally estimated that 10  $\mu\text{m}$  of ablation corrects one diopter of myopia.

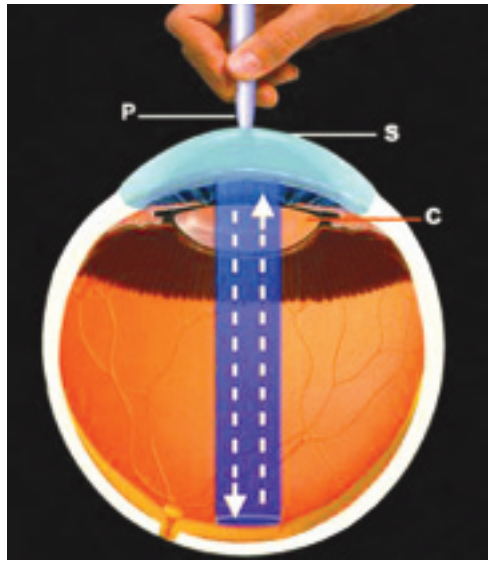


**Fig. 17.6** Illustration of a corneal pachymetry in a patient undergoing LASIK. P, ultrasound pachymeter; A, flap depth in case of LASIK; B, amount of stroma ablated for correction of refractive error; C, residual bed thickness. (From Boyd, BF. Pre-operative evaluation and considerations. In: Atlas of Refractive Surgery. Highlights of Ophthalmology, 2000, 45. Courtesy Jaypee Highlights Medical Publishers Inc., Panama.)

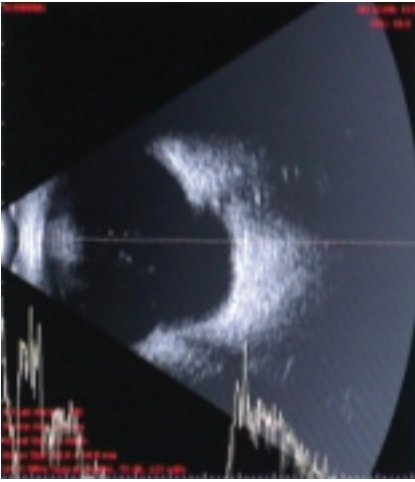
## ◆ A-Scan Ultrasonography

Ocular biometry must be performed prior to cataract surgery. Biometry is the discipline in charge of the physical parameters of the eyeball and includes two fundamental explorations, keratometry and the axial length measurement of the eye. Usually, in clinical practice, the term *biometry* refers to the latter and considers keratometry to be a separate procedure.

There is no question that when well selected and properly done the modern methods of partial coherence interferometry (optical coherence biometry), the pentacam (Oculus, Inc., Lynnwood, WA) and the advance contact and immersion ultrasonography afford us the best way of achieving the desired postoperative refraction. Determination of intraocular lens power through meaningful keratometric readings and axial length measurements has become the standard of care. This is a challenging technique to obtain good visual results and patient satisfaction (Fig. 17.7).



**Fig. 17.7** Determination of intraocular lens power in patients with normal axial length (normal eyes)—mechanism of how ultrasonography measures distances and determines axial length. The use of ultrasonography to calculate the intraocular lens power takes into account the variants that may occur in the axial diameter of the eye and the curvature of the cornea. The ultrasound probe (P) has a piezoelectric crystal that electrically emits and receives high-frequency sound waves. The sound waves travel through the eye until they are reflected back by any structure that stands perpendicularly in their way (represented by *arrows*). These *arrows* show how the sound waves travel through the ocular globe and return to contact the probe tip. Knowing the speed of the sound waves and based on the time it takes for the sound waves to travel back to the probe (*arrows*), the distance can be calculated. The speed of the ultrasound waves (*arrows*) is higher through a dense lens (C) than through a clear one. Soft-tipped transducers (P) are recommended to avoid errors when touching the corneal surface (S). The ultrasonography equipment computer can automatically multiply the time by the velocity of sound to obtain the axial length. Calculations of intraocular lens power are based on programs such as SRK-II, SRK-T, Holladay, or Binkhorst, among others, installed in the computer. (From Boyd, BF. IOL power calculation in normal cases. In: *The art and science of cataract surgery. Highlights of Ophthalmology*, 2001, 41. Courtesy Jaypee Highlights Medical Publishers Inc., Panama.)



**Fig. 17.8** Mode B-scan showing retinochoroidal coloboma.

### ◆ B-Scan Ultrasound

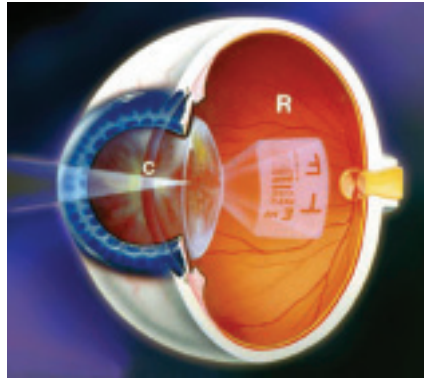
Linear A scans are summated in the B-scan. This gives a two-dimensional cross-sectional image of the eye and orbit. It is of great value in evaluating the posterior segment in eyes with opaque media (**Fig. 17.8**).

### ◆ Potential Acuity Meter Testing

The Potential Acuity Meter (PAM; Marco Ophthalmic Inc., Jacksonville, FL) is an instrument that attaches to a slit lamp. It serves as a virtual pinhole by projecting a regular Snellen visual acuity chart through a very tiny aerial pinhole aperture ~0.1 mm in diameter. The light carrying the image of the visual acuity chart narrows to a fine 0.1-mm beam and is directed through clearer areas in cataracts (or corneal disease), allowing the patient to read the visual acuity chart as if the cataract or corneal disease were not there. The PAM is taken from its stand and placed directly onto the slit lamp in the same manner as the detachable type of Goldmann tonometer. The examination takes from 2 to 5 minutes per eye, depending on the density of the cataract (**Fig. 17.9**).

As pointed out by Guyton, for the PAM to work adequately, there must be some small hole in the cataract for the light beam to pass through. You may find such a hole even in cataracts that have media clouding of up to 20/200 and better. When you find it, then you can avoid the light scattering produced by the opacities. It is this light scattering that washes out the retinal image and decreases vision behind cataracts. By projecting the image of the visual acuity chart through one tiny area, we avoid the scattering effect, and the patient can see the chart.

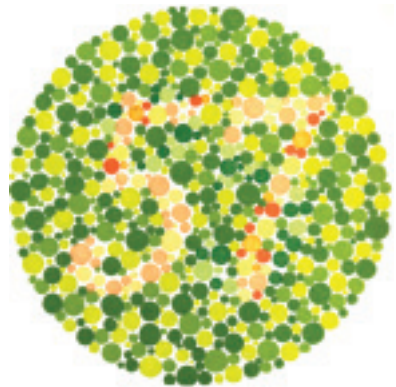
**Fig. 17.9** Potential Acuity Meter Guyton Test. C, cornea; R, retina. (From Boyd, BF. Preoperative evaluations. In: The art and science of cataract surgery. *Highlights of Ophthalmology*, 2001, 16. Courtesy Jaypee Highlights Medical Publishers Inc., Panama.)



### ◆ Color Vision Tests (Ishihara Plates, Depth Perception Tests)

People with normal cones and light sensitive pigment (trichromasy) are able to see all the different colors and subtle mixtures of them by using cones sensitive to one of three wavelengths of light—red, green, and blue. A mild color deficiency is present when one or more of the three cones' light sensitive pigments are not quite right and their peak sensitivity is shifted (anomalous trichromasy—includes protanomaly and deuteranomaly). A more severe color deficiency is present when one or more of the cones' light sensitive pigments is really wrong (dichromasy—includes protanopia and deuteranopia).

The Ishihara test, for example, is composed of a series of colored cards on which numbers or lines of equal shade can be read by a person with normal color vision but not by someone with defective color vision. It makes use of the peculiarity that in red-green blindness, blue and yellow appear remarkably bright compared with red and green. The color plates are encased in a specially designed album-type book for ease of handling. The set includes four special plates for tests to determine the kind and degree of defect in color blindness. This color blindness test is accepted by leading authorities (**Fig. 17.10**).



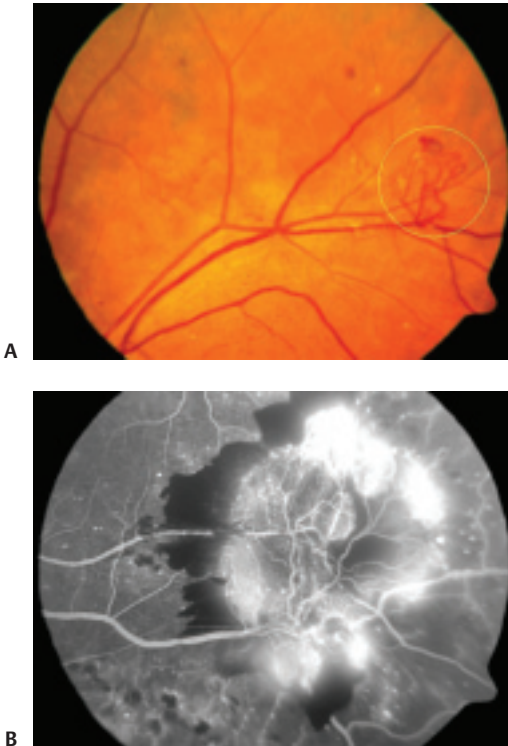
**Fig. 17.10** Ishihara plate.

## ◆ Fluorescein Angiography

Fluorescein angiography can be a very useful procedure for assessing retinal disease by delineating areas of involvement, guiding treatment, and formulating a prognosis for changes in the patient's vision.

To interpret fluorescein angiographic images, knowledge of retinal/choroidal anatomy and circulation is essential. Arterial and venous circulation differences, as well as the retina's barriers against the passage of sodium fluorescein (NaFl) dye, including the retinal pigment epithelium (RPE) (outer blood-retinal barrier) and the retinal vascular endothelium (inner blood-retinal barrier), must be understood. Knowledge of fundus pathophysiology and anatomy has been greatly enhanced by research using fluorescein angiography (**Fig. 17.11**).

For purposes of angiogram interpretation, the sensory retina can be divided into vascular and avascular portions. The vascular portion is composed of the internal limiting membrane (ILM), nerve fiber layer (NFL), ganglion cell layer (GC), inner plexiform layer (IPL), and inner nuclear layer (INL). These portions of the retina receive direct metabolic support from retinal blood vessels.



**Fig. 17.11** (A) Fundus photo of neovascularization. (B) Fluorescein angiography of neovascularization.

The sensory retina's avascular portion consists of the outer plexiform layer (OPL), the outer nuclear layer (ONL), and rod and cone photoreceptor cells. These structures receive metabolic support from the choroidal vessels via the pigment epithelial cells.

## ◆ Optical Coherence Tomography

Optical coherence tomography (OCT) is an imaging modality that performs high-resolution, micrometer-scale cross sections of the eye and other biological structures.

At this time the technology is analogous to B-scan ultrasound. Its utility to the clinician lies in the ability to accurately make noninvasive anatomical measurements *in vivo* (Fig. 17.12). Prior to the development of OCT, the mainstays of clinical examination for many retinal diseases were slit-lamp biomicroscopy, fundus photography, fluorescein angiography, and indocyanine green angiography. Although these diagnostic techniques remain essential to diagnosis and management, OCT has emerged as an invaluable diagnostic tool as well, providing quantitative and qualitative information that was previously unattainable.

In addition to presenting a clearer picture of the pathophysiology of disease, OCT has been extremely useful in determining response to therapy. Multiple studies, for example, have used OCT to examine ocular response following macular treatments determining that there is an initial increase in subretinal and intraretinal fluid, followed by a gradual decline over the next days.

## ◆ Lasers In Ophthalmology

### Laser Peripheral Iridectomy

Because of the coagulating effect of argon laser light, iridectomy performed by argon laser offers advantages over incisional iridectomy or neodymium:yttrium-aluminum-garnet (Nd:YAG) laser iridectomy in patients predisposed to bleeding conditions, such as those taking anticoagulants or with known blood-clotting disorders. The laser iridectomy is performed as an office procedure in a closed eye—a considerable advantage over surgical iridectomy (Fig. 17.13).

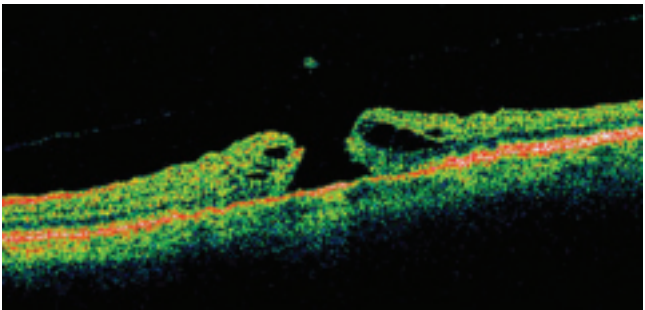
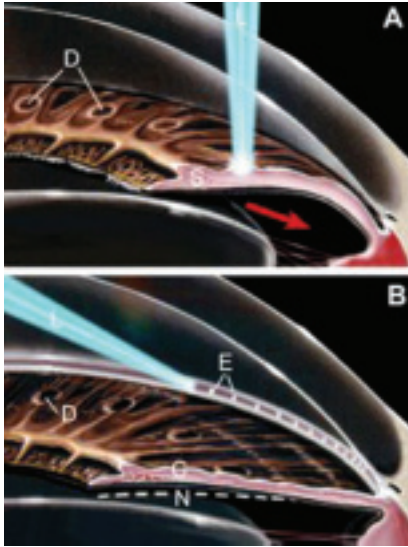


Fig. 17.12 Optical coherence tomography of a macular hole.





**Fig. 17.13** Iridectomy with argon laser—opening a narrow angle in chronic, narrow angle glaucoma. A laser iridectomy is the procedure of choice for narrow angle glaucoma except in cases such as (A) where the peripheral iris lies too close to the cornea for treatment. Laser applications (D) are placed in the midstroma area of the iris to open the angle. These non-perforative laser applications cause heat, which in turn causes shrinkage of the iris collagen fibres in the direction of the arrow. The iris sphincter muscle (S) and the laser beam (L) are shown in (B), shrinkage from laser applications (D) has opened the angle to an acceptable position (C). A peripheral laser iridectomy is then executed. The normal iris location is shown on dotted line (N). The angle is now sufficiently open for laser trabeculoplasty if indicated. Laser beam (L) is shown producing burns (E) in the now visible trabeculum. (From Boyd, BF, Luntz, M. Acute and chronic angle closure. In: Innovations in the glaucomas. *Highlights of Ophthalmology*, 2002, 277. Courtesy Jaypee Highlights Medical Publishers Inc., Panama.)

It is an effective way of producing an opening in the iris but should not be used while the eye is congested or inflamed. Clear media are essential. The eye is prepared with topical anesthesia. The surgeon should have comfortable arm supports.

The Abraham technique is highly useful and effective. These burns immediately cause iris contraction and put the iris crypt on stretch. Other surgeons find that the stretch burn is generally unnecessary if the Abraham contact lens is used.

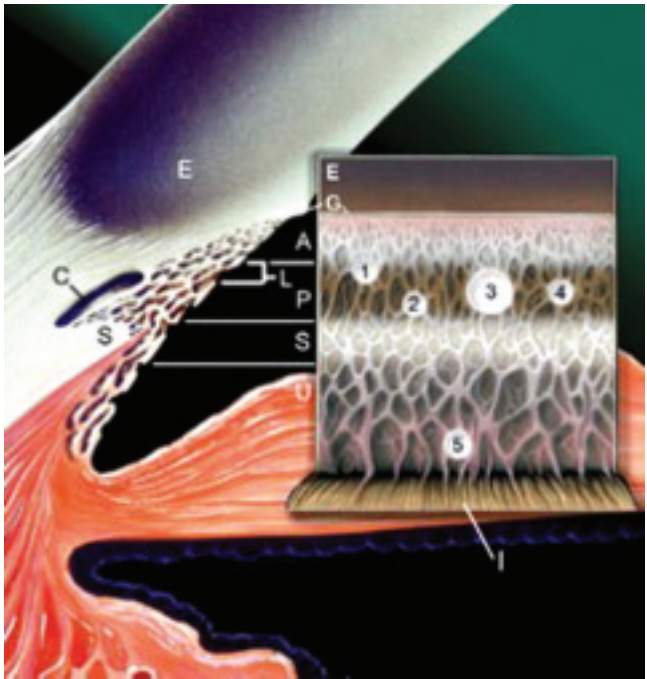
In the majority of cases, an iridectomy is achieved at the first session. As penetration of the iris stroma reaches the pigmented epithelium of the iris, bursts of pigment appear in the anterior chamber ("smoke signals"). Power is then reduced, and further burns are applied until a mushroom cloud of aqueous and pigment balloons through the iridectomy, indicating penetration of the iris.

### Argon Laser Trabeculoplasty

The Glaucoma Laser Trial, a major prospective, randomized study, concluded that laser trabeculoplasty as an initial treatment for open-angle glaucoma is as safe and as effective as medical treatment. In some cases, it may be more appropriate as initial therapy. These cases include (1) patients who cannot or will not comply

with prescribed medical therapy, (2) areas of the world where adequate medical treatment is unfeasible because of poverty.

In all cases, to be successful, the angle does have to be open, the media must be clear, and one must have access to the trabecular meshwork. James B. Wise, M.D., who developed argon laser trabeculoplasty (argon laser trabeculoplasty), has observed that population groups of phakic patients do better than aphakic. It appears that aphakia does interfere with response to the laser, probably by the influence of vitreous in the anterior chamber and the trabecular meshwork. Interestingly enough, pseudophakic patients respond to the laser very similarly than phakic patients. That is, the presence of the posterior chamber lens implant keeping the vitreous out of the anterior chamber greatly improves the response to the laser. Eyes with anterior chamber lenses and glaucoma usually show a poor laser response due to uveitis and trabecular damage from the lens (Fig. 17.14).



**Fig. 17.14** Applying laser burns correctly in argon laser trabeculoplasty. Cross section to the left; cornea (E), Schlemm canal (C), scleral spur (S), Schwalbe line (G), anterior corneal-scleral meshwork (A), pigmented band (P), and uveal meshwork (U). Proper placement of the 50  $\mu\text{m}$  laser burn (L) is shown at the posterior margin of the pigmented band (P). To the right is a gonioscopic view with iris (I) below. Properly placed 50  $\mu\text{m}$  laser burn at the posterior pigment band (P) shown at (1). Another burn is shown at (2) along the posterior margin of the pigment band (P). An oversized burn is shown at (3), spanning the entire pigment band. A slightly misplaced burn is shown at (4) in the middle of the pigment band. A seriously misplaced burn into the uveal meshwork (5). (From Boyd, BF, Luntz, M. Argon laser trabeculoplasty. In: *Innovations in the glaucomas. Highlights of Ophthalmology*, 2002, 149. Courtesy Jaypee Highlights Medical Publishers Inc., Panama.)

## Retinal Laser Photocoagulation

Many significant applications have been discovered for clinical use of the laser in ophthalmology. The unique features of the eye allowing intraocular transmission and selective absorption of light energy account for a wide range of laser treatments.

Essentially, treatment may be categorized into five general effects: (1) induction of chorioretinal burns or retinal scar that lead to (possible pharmacological) neutralization of ischemia-induced retinal neovascularization; (2) reduction in retinal vascular permeability via direct vascular closure or unknown mechanisms; (3) ablation of undesired tissue such as choroidal neovascularization, tumors, abnormal native vessels, or aqueous-producing tissue; (4) induction of a chorioretinal scar that may serve as a barrier to extension of subretinal fluid; and (5) lysis of traction-inducing or media-opacifying tissues (**Fig. 17.15**).

The techniques of laser photocoagulation include the following broad categories: scatter treatment, focal treatment, ablative treatment, demarcating treatment, and cutting treatment.

### *Focal Macular Treatment*

Macular edema occurs from a variety of disease mechanisms, but the feature common to each is increased retinal vascular permeability. Contributing factors include retinal ischemia, inflammation, and traction. Some entities in the first of



**Fig. 17.15** Argon laser treatment of a retinal tear (T). (From Cortez, R. Management of retinal detachment. In: Retinal and vitreoretinal surgery. *Highlights of Ophthalmology*, 2002, 402. Courtesy Jaypee Highlights Medical Publishers Inc., Panama.)

these categories are responsive to focal laser treatment: clinically significant diabetic macular edema and branch vein occlusion-associated macular edema. Macular edema due to central vein occlusion may resolve after treatment, but this is not usually accompanied by a visual benefit.

### Nd:YAG Laser Posterior Capsulotomy

Posterior capsule opacification (PCO) is currently the most frequent postoperative complication in cataract surgery.

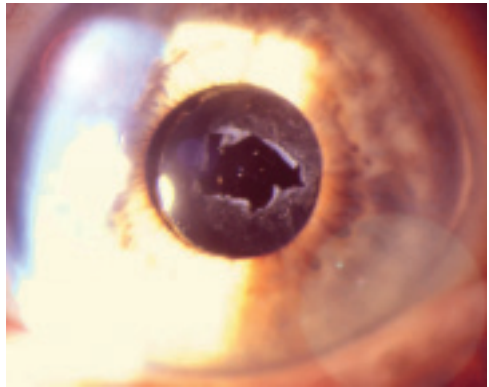
The use of hypotonic solution and preservative free lidocaine are being investigated in the prevention of PCO. Studies with in vivo specular microscopy suggest that a hydrophilic acrylic intraocular lens would have higher biocompatibility than the hydrophobic acrylic lens, contrary to some previous studies, which affirmed that hydrophobic acrylic lens had higher biocompatibility.

*Opacification of the posterior capsule* is an inadequate term because it is not the capsule that opacifies but an opaque membrane that grows, originating from the epithelial cells that were retained, which proliferate and migrate on the posterior capsule (**Fig. 17.16**).

The pearls of Elschnig originate from the superimposed epithelial cells of the flexible wing of the anterior capsule and migrate to the posterior capsule.

Opacification of the posterior capsule is treated with Nd:YAG laser, which is a photodisruptor laser. In other words, it uses a high pulse of ionizing electromagnetic energy to break the tissue.

To achieve the opening of the capsule, begin from the periphery at 12 o'clock and go to 6 o'clock with a size larger than the pupil (undilated). Make the incision going from 3 o'clock to 9 o'clock using the Abraham lens. Finally clean the residues to avoid leaving floating fragments.

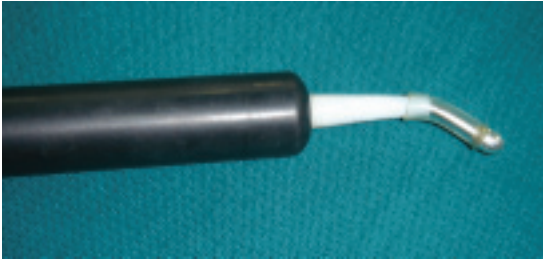


**Fig. 17.16** Nd:YAG laser posterior capsulotomy.

## ◆ Cryoprobes

Cryoprobes are used for peripheral retinopexy in patients with peripherally located retinal breaks and tears, in the treatment of retinal tumors and retinal vascular malformations. They have also been used for performing cyclocryotherapy in end-stage glaucomas.

The tip of the probe is placed over the globe at the edge of the break while visualizing with the indirect ophthalmoscope. The freezing is then applied until there is whitening of the retina (freezing of the vitreous should be avoided). Once the tip has thawed, it is removed and the next application is made (**Fig. 17.17**).



**Fig. 17.17** Cryoprobe.