tutorial

Fundus photography and fluorescein angiography

The photographic procedure

General procedure

All fundus cameras, regardless of the manufacturer, require that the eyepiece be set for the refractive error of the photographer in order to insure proper focusing of the retinal image onto the film. This should be the first task that is undertaken when beginning work with a fundus camera. This setting may be achieved with or without any corrective lenses that are ordinarily worn. The setting will remain unchanged as long as the refractive error has not changed. What is important is that all photographic work be carried out under the same conditions that prevailed when the eyepiece setting was determined.

It is important to note that all fundus photography must be done without any accommodation on the part of the photographer. This means that the photographer should try to relax the gaze as if looking at an object at infinity. Some young people may experience considerable difficulty at the outset of their fundus photography work in that accommodation may cause their pictures to be unsharp. The age and the degree of inherent elasticity of the eye lens is invariably the cause of the involuntary accommodation that takes place in the young photographer’s eye. It is strongly recommended that both eyes be kept open when working with the camera and that the eyepiece setting and technique of focusing both the image and eyepiece crosshairs be strictly followed (Wong, 1976). A further discussion of focusing follows.

Determining the eyepiece setting

To determine one’s eyepiece setting, dim the room illumination and place a piece of plain white paper over the front lens of the fundus camera to act as a reflector. Rotate the eyepiece all the way out. Next, look into the eyepiece with both eyes open and looking at infinity. With smooth, uniform motions, turn the eyepiece inwards until the crosshairs within the eyepiece are seen sharply. Stop, and make a note of the setting. Repeat the procedure twice more and determine the average reading. If the readings are spread over a wide range, accommodation is taking place, which is an indication that difficulty in obtaining consistently sharp pictures will most probably be encountered. It is important that the movements utilized to rotate the eyepiece inwards be smooth and uniform rather than short and jerky. Most importantly, do not rotate the eyepiece past the point where it is determined that the crosshairs have appeared sharpest, and turn backwards. Though this is standard and accepted practice when working with conventional photographic cameras and enlargers, it is probably the worst technique that can be applied in this situation. Turning the eyepiece hack and forth may cause involuntary accommodation, which will result in the determination of an incorrect setting.

Adjusting the fundus camera and the camera table

Next, the photographer should become familiar with the controls of the apparatus and should be given frequent exposure to fundus photography. A continual program of training is required to produce a proficient fundus photographer. Then, it takes a great deal of work with the camera to develop the expertise necessary to perform fluorescein angiography well and to produce consistently good results. It is quite unfair to the photographer to expect top quality results without a considerable amount of practice. The full-time ophthalmic photographer generally performs the procedures frequently enough to gain proficiency; however, it is a common occurrence to find that biomedical photographers who staff a central photographic department are called upon to do fundus photography or even fluorescein angiography on only an occasional basis.

It is important that each person evolve a routine for fundus photography
which is adhered to faithfully throughout each patient procedure. In this way, it is possible to minimize the number of errors. The following procedure has worked well for me:

1) Adjust the camera table height so that both patient and photographer may be seated comfortably.

2) Check over the apparatus for the following:
   a) Correct eyepiece setting, as previously determined.
   b) Correct film type in the 35 mm camera body.
   c) Appropriate shutter speed dial setting for electronic flash synchronization.
   d) Correct flash output setting on the power generator.
   e) Correct filters for angiography.

3) Turn the power switch on.

4) Place a fresh chinrest pad onto the rest or wipe the chinrest with a tissue. Bring the patient into position in the headrest and chinrest assembly.

5) Adjust the chinrest assembly so that the patient's eyes are at a level about one inch below the headrest bar. This places the camera so that the elevation and depression control knob on the camera table top is in its mid-range, and therefore permits continuous adjustments to follow eye movements during the photographic session. In this way, if the eye moves slightly up or down, the illuminating beam may be kept in alignment with the dilated pupil by quick, compensating movements of the elevation and depression knob.

6) Tell the patient about the procedure, what it is he is about to have done, how it is done and what his role is. An informed patient generally is capable of better cooperation. Instruct him to maintain constant contact with the headrest bar and to rest firmly down on the chinrest, keeping the mouth closed and teeth together once photography has started. As simple and unimportant as it may seem, many patients express great relief when informed that they may breathe and blink normally during the photographic session.

7) Direct the camera at the eye to be photographed, while asking the patient to gaze at the fixation target light with the fellow eye. It is important to determine the patient's capability in being able to see the target light and to maintain a fixed gaze at it. It must never be forgotten that the patients with whom we work may have difficulty in seeing the target light or maintaining a fixed gaze at it, either through loss of central visual acuity or simply due to poor concentration. Often, with certain types of target lights, the patient will be gazing at the light and the eye to be photographed will turn inwards toward the nose. This overconvergence may be due to the fact that because the fixation light is placed so close to the patient's face, he is trying to see it with both eyes. After several attempts, if the eye to be photographed still converges, ask the patient to sit back for a rest. Upon returning to position occlude the eye to be photographed while directing the target light at the fellow eye (Figure 15).

8) Align the camera with the eye so that the coils of the filament of the focusing lamp are rendered into sharp focus on the cornea and the light passes into the eye through the center of the dilated pupil. This will yield an evenly-illuminated field of view. Since each fundus camera is designed to work at a specific distance to the eye, focusing these coils on the cornea grossly establishes this distance.

9) All previous steps were accomplished by looking directly at the patient. Now the photographer may look into the eyepiece, and even if the field is

Figure 15—For those patients with difficulty following the fixation light with the fellow eye, the eye being photographed can be occluded to help the patient locate and visualize the light.
Figure 16—Focusing on both the crosshairs and the image is sometimes difficult for young photographers due to accommodation. A—Sharp image of the fundus. B—Sharp image of crosshairs. In A and B the photographer may have seen both the image and the crosshairs in focus through accommodation, but an unsharp image was recorded on film. C—Correct focusing technique with a sharp image of the crosshairs superimposed on a sharp image of the fundus.

not evenly illuminated, if the fundus can be visualized, quickly focus the image. Three conditions exist which may influence this focusing procedure (Figure 16):

a) The photographer may see the patient’s fundus well, but may not be aware of the crosshairs in the eyepiece.

b) The photographer may see the crosshairs sharply, but may not see a sharp image of the fundus.

c) The photographer sees a sharp image of the crosshairs superimposed over a sharp image of the fundus. Only condition c, combined with the proper determination of the photographer’s eyepiece setting will insure that a well-focused image will be obtained on film. Any accommodation that occurs in the photographer’s eye during the procedures may result in unsharp pictures. The beginner may find it easiest to achieve a quick and fairly critical focus by focusing on the light reflexes that are seen on the major blood vessels. This technique will yield satisfactory results and is acceptable while the photographer is going through a period of orientation and learning. As experience is gained, however, a more critical focus should be sought by focusing on the texture of the pigment epithelial layers in the foveal area when photographing the posterior pole and by utilizing the astigmatic correction control (if available). A fair degree of improvement in the image quality of angiograms done of the posterior pole is noted when this latter technique is used.

10) Once the image has been focused, the photographer can adjust the camera for critical illumination. By manipulating the controls on the camera table, namely the elevation and depression knob and the joystick, position the camera so that the light beam passes through the center of the dilated pupil. This has been done grossly, prior to focusing. If the patient cooperation has been good, the field should still be evenly illuminated, with no color fringes around the picture margins. If the eye has moved, realignment of the camera is necessary. Move the joystick towards and away from the patient in very line movements, and lock its position when the deepest tone of color is seen. This is optimum camera position. Make the exposure with the least amount of delay.

11) Cock the shutter and advance the film in order to be ready for the next photograph.

Peripheral fundus photography

The term “peripheral fundus photography,” as ophthalmic photographers tend to use it, is actually a misnomer, since the conventional fundus camera is not capable of producing photographs of the peripheral fundus without the use of special techniques. Therefore, any photography outside of the central field (posterior pole) is commonly referred to
as “peripheral fundus photography” by photographers.

The same photographic requirements apply to this type of photography as to photography of the central field, yet the photographic procedures that are required are more difficult and require more precise camera manipulation than when photographing the central field. The degree of difficulty in taking peripheral fundus photographs is generally proportional to the distance away from the posterior pole. In the quadrants just adjacent to the posterior pole, the area of interest may be located simply by changing the position of the fixation target light. As the fixation light is moved from one position to another, the patient follows the movement, keeping his head in the normal position in the headrest, while the photographer realigns the camera to keep the field in view. Since the peripheral cornea and lens are being utilized to form the images, the use of an astigmatic correction control becomes more important in order to obtain a well-resolved image. If no such control is available, the selection of a proper plane of focus becomes critical. It is important to retract the lids and lashes away from the optical pathway in these views because the pupillary area is no longer circular, but rather becomes elliptical. This elliptical pupil also moves further away from the widest part of the palpebral fissure, either superiorly, inferiorly or to the lateral margins, which are narrower.

Illuminating fields just adjacent to the posterior pole is not difficult at all. However, as one proceeds further out into the periphery, it may not be possible to obtain an evenly illuminated field. It is also not always possible to obtain a picture that is sharply focused throughout.

The patient, though cooperative for posterior polar views, may not be capable of offering that same level of cooperation for peripheral photography simply because he may not be able to keep the degree of muscular control over the direction of gaze long enough to maintain fixation at the target light. Under these circumstances, the availability of a tilt mechanism on the fundus camera makes the job considerably easier (Figure 17), since the camera may be tilted up or down, permitting the patient’s gaze to be directed more centrally. If no tilt mechanism is available, one may try another approach. For a superior quadrant, elevate the entire table higher than usual and ask the patient, to allow the forehead to tilt away from the forehead bar, keeping the chin firmly in contact with the chinrest. If the area of interest is in the inferior quadrant, lower the table and ask the patient to maintain contact with his forehead against the forehead rest, allowing the chin to move hack away from the chinrest while tilting his head downwards. In both of these instances, the camera must be advanced toward the patient in order to maintain the critical working distance to the cornea that is required for reflex-free photographs. These techniques are limited by the degree of movement that the camera has in being able to achieve the critical working distance.

When doing peripheral fundus photography, and especially in those situations where one must study the peripheral lesion angiographically, it is helpful to have very specific instructions from the.

Figure 17—Positioning of the Fundus camera for peripheral fundus photography using the tilt mechanism on the Zeiss camera. It is important to use the astigmatic correction control for photography of fields adjacent to the posterior pole. A—Positioning with tilting mechanism for inferior view. B—Positioning for superior view obtained by tilting the camera.
physician as to the location of the lesion. It is therefore advisable for the photographer to prepare an appropriate photographic requisition form for fundus photography and fluorescein angiography, on which the physician can provide explicit instructions as well as a sketch of the area of the fundus to be studied.

Often, it would simplify the task of locating the lesion if the photographer could observe the lesion while the physician is examining the patient. This may be done by utilizing the observer’s mirror attached to the headset of the physician’s indirect ophthalmoscope. The practice of observing during the physician’s examination often eliminates a lengthy preliminary procedure on the part of the photographer. The patient does not have to sit at the camera while the photographer scans and searches for the area of interest. This will also insure a study of the proper field. After the physician has located and identified the lesion for the photographer, the patient may be moved to the camera for photography.

Systemic diseases such as diabetes and hypertension may cause widespread involvement of the fundus, and the only way to properly document this type of retinopathy is to provide numerous overlapping views of as much of the fundus as can be photographed. These “survey” views ideally should be standardized so as to be easily and readily duplicated from one lab to another. Recognizing this, the investigators of the federally sponsored study on diabetic retinopathy, the Diabetic Retinopathy Study (DRS), have provided a photographic protocol which defines these fields (Anon., 1976). I would recommend that all fundus photographers familiarize themselves with the seven standard fields of the DRS and adhere to the protocol when doing peripheral fundus photography.

In brief, the seven standard fields of the Diabetic Retinopathy Study are defined as follows (Figure 18):

**Field 1—Disc.** Center of optic disc at intersection of crosshairs in the ocular.

**Field 2—Macula.** Center of macula at intersection of crosshairs in the ocular.

**Field 3—Temporal to macula.** Nasal end of horizontal crosshair at center of macula.

**Field 4—Superior temporal.** Lower edge of field tangent to a horizontal line passing through upper edge of optic disc, and nasal edge of field tangent to a vertical line passing through center of disc.

**Field 5—Inferior temporal.** Upper edge of field tangent to a horizontal line passing through lower edge of optic disc, and nasal edge of field tangent to a vertical line passing through center of disc.

**Field 6—Superior nasal.** Lower edge of field tangent to a horizontal line passing through upper edge of optic disc, and temporal edge of field tangent to a vertical line passing through center of disc.

**Field 7—Inferior nasal.** Upper edge of field tangent to a horizontal line passing through lower edge of optic disc, and temporal edge of field tangent to a vertical line passing through center of disc.

Figure 18—The seven standard fields of a right eye from the Diabetic Retinopathy Study (DRS) illustrated with a schematic diagram and photographs. Field 1—Disc. Field 2—Macula. Field 3—Temporal to macula. Field 4—Superior temporal. Field 5—Inferior temporal. Field 6—Superior nasal Field 7—Inferior nasal.