METHODS FOR OBSERVATION OF THE FUNDUS

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INTRODUCTION

This chapter includes a review of:

- Fundus Biomicroscopy
- Binocular Indirect Ophthalmoscopy
- Monocular Indirect Ophthalmoscopy

FUNDUS BIOMICROSCOPY

Alternative names:

- Slit Lamp Indirect Ophthalmoscopy
- Biomicroscopic Indirect Ophthalmoscopy Auxiliary Lens Retinal Evaluation.

DESCRIPTION

Fundus biomicroscopy is a procedure used to examine the retina and posterior 2/3 of the vitreous using the biomicroscope with auxiliary lenses. The auxiliary lenses bring the image of the fundus into focus. The biomicroscope, with its illumination and observation systems, provides the binocularity, magnification, illumination and coverage needed for optimal examination of the retina. The procedure is now the **standard of practice** for both routine and problem specific detailed examination of the fundus. Fundus biomicroscopy is most often used to examine the posterior pole but can also be used to examine the peripheral retina especially when a closer assessment of findings is required. Its advantages are summarized in the following table.

• Binocular stereoscopic view	• Undilated view possible
• Posterior pole and peripheral views	• Available accessories (tints, reticules, holders)
• Wide field of view (lens dependant)	• High resolution
• Variable illumination	• Multiple lens options
• Variable magnification	• Contact and non-contact versatility

Table 3.1: *Advantages of fundus biomicroscopy*

THEORY AND INSTRUMENTATION

Indirect Methods

The indirect method uses high plus auxiliary lenses to focus light from the retina to form an image in a plane between the lens and the biomicroscope. The biomicroscope is used to view the image which is **aerial, real, reversed and inverted** (Fig. 3.1). The main advantage over direct methods is the elimination of the pupil as a field stop, therefore producing a **wider field of view**.

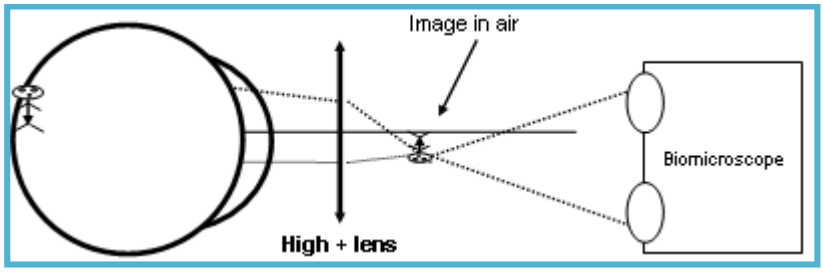

Figure 3.1: *Image formation using an indirect method of examination*

A number of indirect lenses are available both to be used in contact and non-contact procedures. Only the mainstream ones will be discussed here.

The +**60D, +78D, +90D** are the most commonly used lenses. These lenses are double aspheric in design to reduce reflections and produce a higher quality image. They are available clear or tinted yellow to improve patient comfort. The yellow lens filters phototoxic blue and violet wavelengths but it will alter the perceived color of fundus findings. Clear lenses are more widely used.
The **SuperZoom 78/90** is simply a zooming telescopic lens that permits shifting from +78D to +90D optics so that the examiner can draw from the advantages of both powers.
The **SuperPupil** XL is designed for use with small pupils such as when dilation is not indicated or is limited (e.g., fixed miotic pupils). It is used in a similar way as the above mentioned lenses but it is held closer to the eye. It allows an equator to equator view without changing the patient's fixation. A special lens design allows the biomicroscope illumination system to be 30° away from the observation system to reduce reflections. It also comes with accessories such as a contact adapter (to maximize the view through small pupils), a lid and a yellow filter adapter.
The **Superfield NC** is also a hand held non-contact high plus lens that allows a wide field of view. It produces a magnification similar to the +90D but increases the field of view. It also comes with a multitude of accessories rendering it extremely versatile. A (+) lens adapter is available to decrease its magnification and increase its field of view. A (-) lens adapter is provided to produce the opposite effect to render it more like a +78D lens.   A reticule is available to facilitate measurement and grading fundus observations. A (+) contact adapter is also available to give it the advantages of contact fundus biomicroscopy by producing a sharper image, reducing reflections, increasing field of view up to the ora and providing increased lid control. A (-) contact adapter provides increased magnification for a detailed disc and macular view.
Several **accessories** are available to make the above lenses more versatile. **Lid-lens adapters** allow the lenses to sit on the patient's external eyelid to provide lens stability, eyelid control and exact positioning for immediate image viewing.

Yellow filters that attach directly onto the lens are available to render patients more comfortable and eliminate phototoxic wavelengths (blue and violet).

A steady **mount** is available to hold and stabilize the **+60D, +78D, +90D** lenses. Although it works well in concert with the natural hand movement, the hand-held method is generally preferred.

The **magnification** (mag.) and **field of view** (FOV) produced varies with the power of the lenses.

The rule is:

↑ Power ↓ Magnification ↑ FOV

Note that the 78D lens has a larger diameter than the 90, so that although magnification is increased, no field of view is lost. The characteristic of the high (+) lenses are shown in the following table:

Lens	Diameter (mm)	Eye-lens distance (mm)	Field of View (°)	Magnification (X)
+ 60 D	31.0	13.0	68	1.15
Super 66	27.0	11.0	80	1.00
+ 78 D	31.0	8.0	81	0.93
+ 90 D	21.5	7.0	74	0.77
SuperField NC	27.0	7.0	95	0.76
SuperPupil	16.0	4.0	103	0.45

Table 3.2: *Comparison of characteristics of lenses*

Advantages	Disadvantages
Excellent optical quality of image	Inverted and reversed image
Detailed magnified view	Difficult to master
Good field of view	Dilation (+/-) needed
Access to the peripheral retina	
Stereoscopic view	
Good contrast	
Independent of patient refraction	
View through dense media is possible	
Lens options and accessories	
Non-contact or contact	
Rapid	

Table 3.3: *Advantages and disadvantages of high (+) lenses*

Procedure

- The patient (preferably dilated) is comfortably aligned behind the biomicroscope with his/her chin on the chinrest and forehead against the forehead rest
- The patient is directed to gaze straight ahead at the examiners ear or at the fixation light
- To facilitate first examinations, low magnification and light intensity settings are used
- A wide parallelepiped beam (2-3 mm width; 7-8mm height) is used
- The biomicroscope illumination is set with the angle coaxial (0°) with the observation system
- The beam is centered and focused on the cornea or slightly in front of it (~5mm)
- The lens is held between the examiner's thumb and index finger
- The left hand is used to hold the lens while examining the right eye and vice versa
- Some lenses are symmetrical and can be used facing either side, while others are designed to be more aspheric on one side to minimize reflections therefore should be used as indicated by the manufacturer (e.g., silver ring indicating side to face patient).
- The examiner observes from **outside the oculars** of the biomicroscope and introduces the lens close to eye just clearing the lashes (Fig. 3.2)
- The lens is centered on the beam so that the light enters the pupil
- The examiner's hand is stabilized by placing his free fingers on the patient's face or on the head-rest
- The examiner's elbow is placed down on the biomicroscope table (a cushion, lens or tissue box is used if the examiner's arm is too short)
- The lids are controlled with the middle finger on the upper lid and the ring finger on the lower lid if needed.
- The examiner then views through the oculars and pulls the biomicroscope straight back until the blurry fundus red reflex becomes apparent
- The examiner continues pulling the biomicroscope back until the retina comes into focus
- The beam height, width and intensity is adjusted to maximize viewing area and minimize patient discomfort
- The lens is tilted slightly to reduce reflections, if necessary
- The entire posterior pole is scanned in a systematic manner (Fig. 3.3) starting with the optic nerve head (ONH) and finishing with the macula; this allows the macula to adapt to the bright light before being examined.

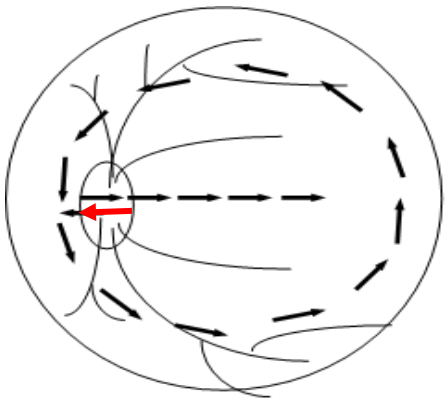

Figure 3.3: *Systematic view of the posterior pole*

TIPS FOR SUCCESS

Remember: the image seen is inversed (right is on left and vice versa) and inverted (upside down) (Fig. 3.4).

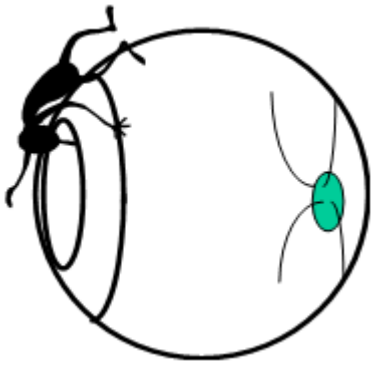

Figure 3.4: *Examiner views inverted and inversed image of the fundus*

- To examine the image of the fundus that has formed in front of the lens, the biomicroscope is moved using the joystick – the lens is not moved
- To view the vitreous, the biomicroscope is moved back keeping the lens in position
- To view the peripheral retina, the patient is directed to change his gaze in the correct direction (e.g., up for a superior view etc.), the lens must then be repositioned in front of the pupil
- With experience, the biomicroscope illumination system can be displaced slightly (<10°) from its coaxial position from the observation system to reduce reflections
- Keep in mind that the lens-eye and lens-biomicroscope distances vary with different lens powers.

Direct Methods

In direct fundus biomicroscopy, high minus powered auxiliary lenses are used to neutralize the power of the eye so that the biomicroscope can focus to the fundus. Direct methods offer the advantage of creating an **erect, virtual image** but the field of view is limited to 5-15° because the pupil acts as an optical field stop. Two main types of direct methods exist, the non-contact Hruby lens and a mirrored or non-mirrored contact lens such as the Goldmann-3-mirror lens.

HRUBY LENS

The Hruby lens is a high -58D lens held in air. The lens is either mounted on the biomicroscope to swing down in front of the observation system or it sits on a rod that fits into a sliding track in front of it. (Fig.3.6). The lens is available as an accessory to many biomicroscopes, but it is an older technique rarely used anymore.

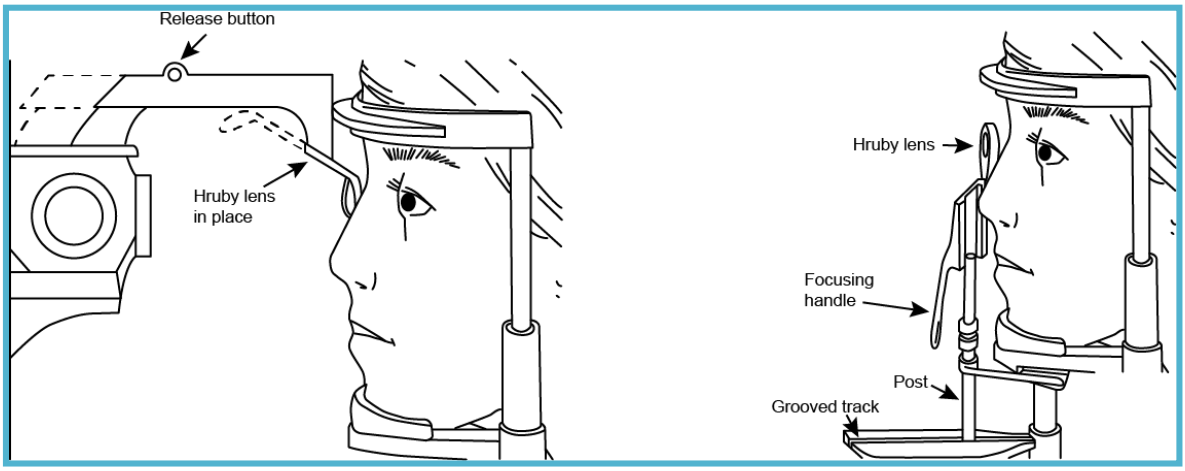

Figure 3.6: *Direct fundus biomicroscopy through Hruby lens*

Drawn from Fingeret M, Casser L, Woodcome HT. Atlas of Primary Eyecare Procedures. Norwalk, CT: Appleton and Lange; 1990.

Advantages	Disadvantages
Non-contact	Limited FOV of 5-8°
Image is erect	Maximal area of exam ~30° (posterior pole)
Easy to learn	Poor optical design – lots of reflections and distortion
Often included with the biomicroscope	Dilation required
Quick method	Difficult on patients with unstable fixation

Table 3.4: *Advantages and disadvantages of the Hruby lens*

Procedure

- The patient is dilated (necessary) and comfortably seated with the chin on the chinrest and head against the headrest of the biomicroscope
- The slit beam is in “click” position (angle of 0° between the illumination system and the observation system) centered and focused on the cornea
- The magnification should be 10X and the slit beam width 2-3 mm. The height of the beam and intensity of the illumination can be varied during the examination
- The lens is positioned with the concave side towards the patient and is placed in the path of the beam of light
- The biomicroscope is moved in toward the patient until the retina is in focus
- The fundus is scanned by having the patient change fixation using the fixation pointer.

GOLDMANN 3-MIRROR (G3M)

The G3M lens is a cone-shaped contact device containing a round concave central surface that is placed directly on the corneo-sleral area of the eye (Fig. 3.7) The central face is actually a -64D lens (Fig 3.8, A) which serves to neutralize the power of the cornea to allow a direct view of the posterior pole (30°). The contact also serves to minimize reflections to allow a crisp clear view. In fact, this and other contact procedures are often utilized to assess questionable areas with greater certainty.

The G3M also contains 3 mirrors inclined at various angles to offer views of the fundus from mid-periphery to far periphery. The inclination angle denotes the angle between the mirror and the front surface of the lens**; the greater the angle of inclination, the more posterior the view.** The trapezoidal mirror (Fig 3.8, B = 76°) allows a view of the equatorial region, the rectangular mirror (Fig 3.8, C = 66°) from the equator to ora, the "thumb-nail" or U-shaped mirror (Fig 3.8, D = 59°) allows the most anterior view from ora to the anterior chamber angle. The images seen in the mirrors are erect but laterally reversed. Many similar lenses are available but the G3M is the most widely used.

Figure 3.7: *The Goldmann 3-mirror lens*

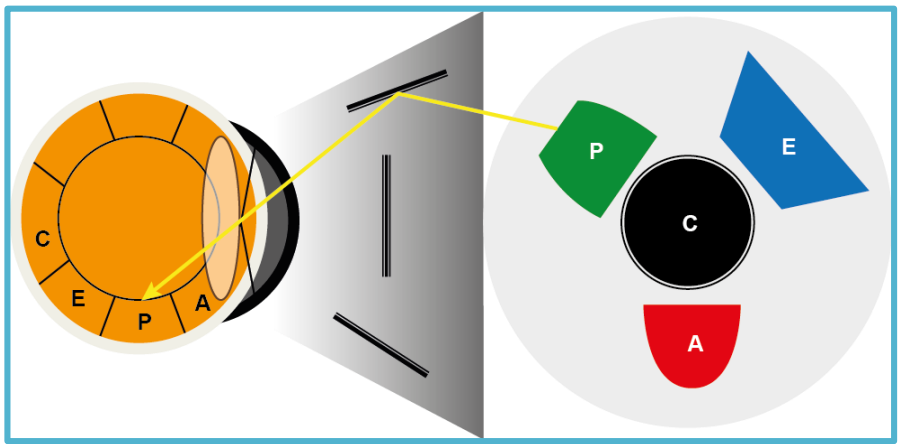

Figure 3.8: *Mirrors used in fundus examination*

Think: **CAPE**

C: Central
A: Anterior
P: Posterior
E: Equatorial

Advantages	Disadvantages
Image is erect	Allows sector views (no panoramic view)
Excellent optical quality of image	Image is laterally reversed through mirrors
Detailed magnified view is obtained	Anesthetic and contact required
Reduced reflections	Dilation required
Stabilizes eye movements	Lens requires disinfection between patients
Reduces blinking interference	More time consuming
Good view of the vitreoretinal interface	Difficult to master technique
	May produce corneal staining or abrasion
	Contra-indications exist • Post-operatively • Traumatic hyphema • Abrasions (+/-)

Table 3.5: *Advantages and disadvantages of the G3M lens*

Procedure (Fig. 3.9)

- The patient is educated, dilated and a topical anesthetic is applied
- The lens is properly disinfected (see Universal Precautions) and rinsed with sterile saline
- 2-5 drops of an appropriate contact fluid (see diagnostic pharmaceutical agents) are placed in the concave surface of the G3M lens
- The formation of bubbles should be avoided; if bubbles are formed, they should be removed with a tissue or the installation of gel should be repeated
- The patient is seated comfortably behind the biomicroscope with the chin on the chinrest and head against the headrest . Do not attempt to insert the lens before the patient's chin is on the chinrest
- The biomicroscope is in "click" position (angle of 0° between the illumination system and the observation system); a 2-3 mm wide parallelepiped beam is used
- The biomicroscope is fully retracted or moved out of the way towards the eye not being examined
- The lens is held with the practitioner's dominant hand while the other hand pulls down the lower lid
- The patient is instructed to look up and the edge of the lens is placed on the inferior cul-de-sac
- The inferior lid is released, the G3M lens holds it down and the upper lid is then pulled up
- The lens is tilted gently upward onto the corneal surface and the upper lid is released.

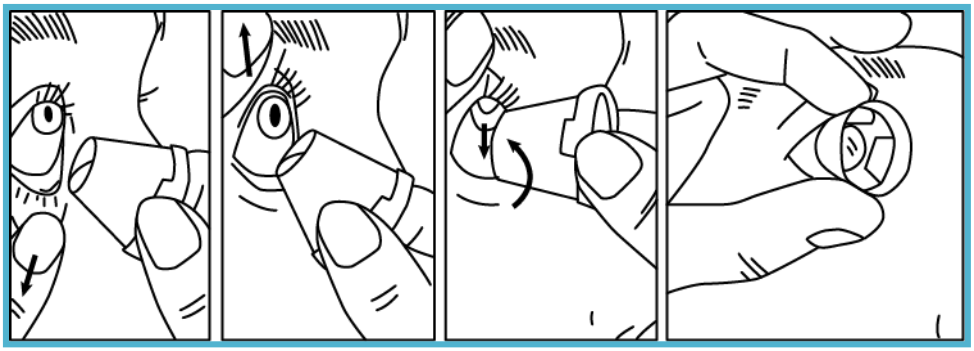

Figure 3.9: *Lens insertion of the Goldmann-3-mirror lens*

Inspired by: Fingeret M, Casser L, Woodcome HT. Atlas of Primary Eyecare Procedures. Norwalk, CT: Appleton and Lange; 1990.

- The patient is instructed to slowly look straight ahead
- If viewing the posterior pole the biomicroscope can be used to focus the retina by moving it towards the patient
- Otherwise, the lens is rotated on the cornea to place the mirror needed 180° away from the area of interest
- For rotation, biomicroscope is released and both hands are used
- Alternatively, 1 hand may be used with the index finger placed on the surface of the lens to hold it in place and the thumb and third finger used to rotate the lens (Fig. 3.10).

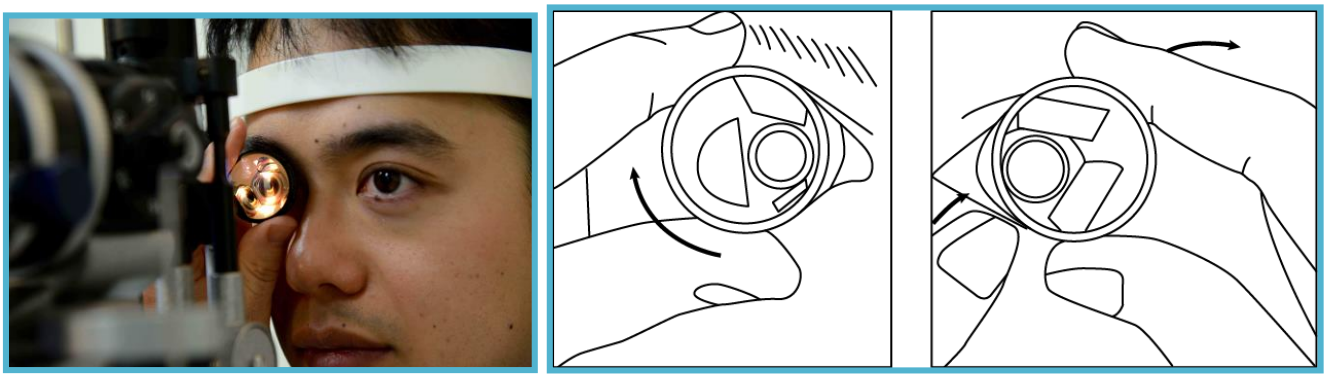

Figure 3.10: *Lens rotation*

Inspired by Fingeret M, Casser L, Woodcome HT. Atlas of Primary Eyecare Procedures. Norwalk, CT: Appleton and Lange; 1990.

- Enough pressure is kept on the lens at all times, to prevent the lens from uncoupling from the surface of the cornea
- The patient's head and fixation are controlled at all times by repeating instructions to the patient and using the free hand to bring the patient back in position if needed
- The examiner may place his elbow down on the biomicroscope table (a cushion, lens or tissue box is used if the examiner's arm is too short) if needed for comfort
- Alternatively, the examiner holds his hand up hanging his fourth and fifth fingers from the headrest for support (this may be less stable)
- The biomicroscope is moved towards the patient with the light beam projected on the desired mirror of the G3M lens
- The examiner moves behind the biomicroscope and moves it toward the patient to obtain a retinal view
- The lens is rotated freely on the cornea and the various mirrors used to examine other areas
- Remember: the desired mirror should be 180° from the area to be examined
- To remove the lens, the patient is asked to look nasally and blink
- If the lens appears "stuck" onto the eye via interface suction, the examiner must not forcibly pull it off; instead, gentle pressure must be applied through the inferior-temporal lid on the globe while pulling the lens in the opposite direction to break the suction
- If preserved contact gel is used for the procedure, the eye must be irrigated with sterile solution or saline
- Note: in situations where an anesthetic is contra-indicated or unavailable for use, a soft contact lens can be used to perform gonioscopy. Although not as comfortable as with the application of anesthetic, it reduces the discomfort and allows the application of the G3M lens.

BINOCULAR INDIRECT OPHTHALMOSCOPY

DESCRIPTION

Figure 3.11: *Binocular indirect ophthalmoscope*

The binocular indirect ophthalmoscope (BIO) is a head borne device (headset or spectacles) that contains an illumination system and viewing oculars (Fig. 3.11). A condensing lens is used to converge the light from the retina to form a **real, aerial, inverted and reversed image** in front of the lens that is viewed through the oculars. The BIO is the single most useful instrument for examining the entire ocular fundus with a panoramic and stereoscopic view (Fig. 3.12) Now considered the **standard of practice,** it complements indirect fundus biomicroscopy in performing a complete fundus examination.

In comparison to direct and monocular indirect ophthalmoscopy, the BIO offers significant advantages as the comparative table below shows:

Ophthalmoscopy	Direct	Monocular Indirect	Binocular Indirect
Stereoscopic view	None	None	Excellent (↓P, ↑stereo)
Field of view	5° (2 DD)	12°	40° (8 DD) with a 20D
Peripheral view	Blurry / impossible	Limited	Excellent
Maximal view	Equator (~60°)	70% of fundus	Beyond ora serrata
Depth of focus	Weak	Fair	Good
Magnification	15 x	5x (fixed)	3x (20D); 2x (30D)
Working distance	Very close (often uncomfortable for the patient)	15-20 cm	Arm's length
Image	Virtual / erect	Real / erect	Real / inversed-inverted
Dilation	Not necessary	Not necessary	Recommended
Ease of procedure	Easy	+/- easy	Difficult

Table 3.6: *Comparison of features of various methods of examination*

THEORY AND INSTRUMENTATION

Illumination and Observation System

Light is projected from the headset and focused through a hand-held lens onto the fundus plane. The light is of variable intensity, spot diameter and color. Some BIOs include a diffuser to soften the edges of the 'spot', expand the field of view, and ease the need for a critical alignment.

A red-free filter is incorporated in most BIOs to enhance the observation of the nerve fiber layer and to facilitate the differentiation of some findings. Pigmented lesions underneath the retinal pigment epithelium (e.g., a nevus) will be indiscernible with the red-free filter. This filter also enhances the observation of hemorrhages and blood vessels. A cobalt blue filter, incorporated for the purpose of performing fluorescein angiography, can be also be used to enhance the detection of buried ONH drusen through induced fluorescence.

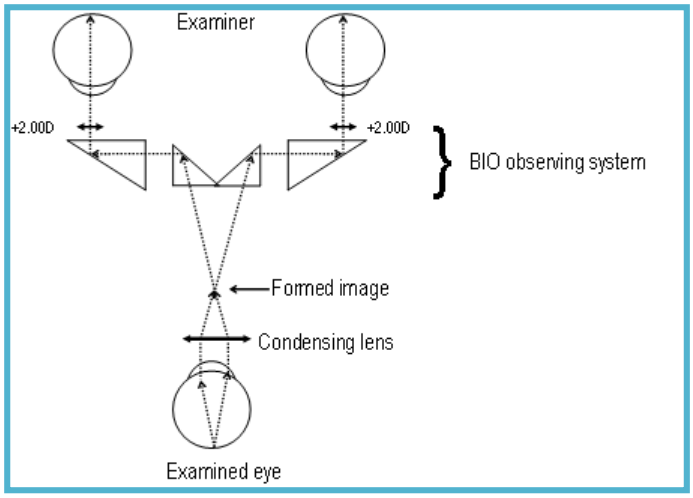

Figure 3.13: *Image formation using a BIO*

The observation system is composed of sets of mirrors and prisms that optically reduce the examiner's pupillary distance to fit it within the patient's pupil along with the illumination beam (Fig. 3.13). This condition is termed pupil conjugacy. One can easily deduct why pupil dilation is strongly recommended to enjoy the full advantages of BIO.

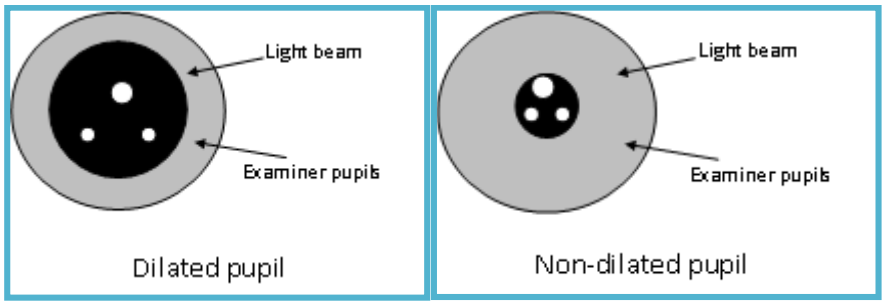

Figure 3.14: *Pupil conjugacy*

Some BIOs provide additional converging ability via prisms to allow BIO to be done on patients with pupils that have not been dilated (Fig. 3.14). A respectable view can be obtained, but it is more difficult as it requires more critical alignment. In addition, better stereopsis is obtained when the images of the examiner's pupils in the patient's pupils are farther apart (smaller ocular PD).

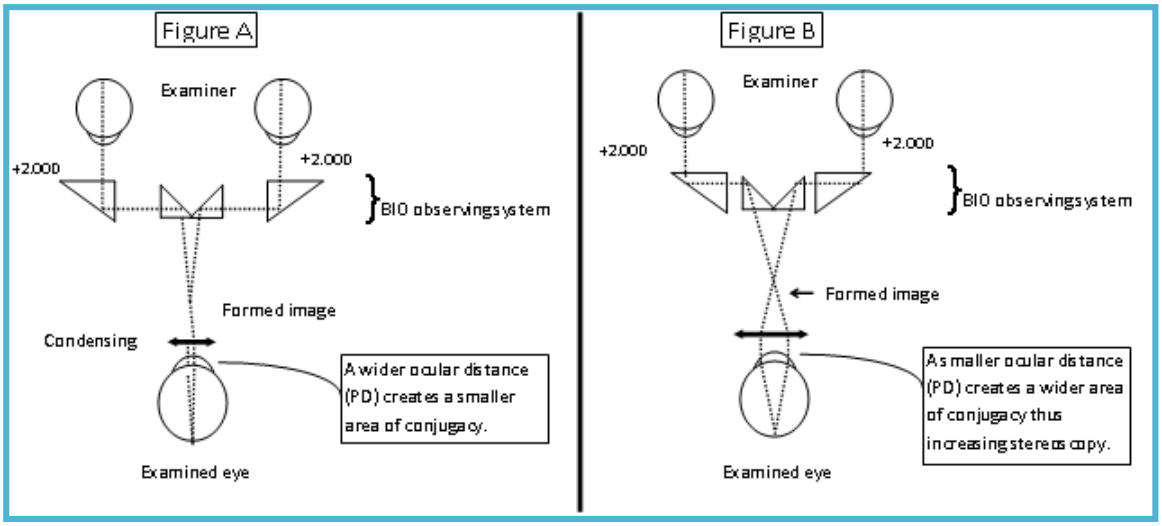

Figure 3.15: *Effect of ocular distance on the BIO view*

To maintain stereopsis in the most peripheral views, some adjustments are necessary. Pupil conjugacy becomes more difficult because the apparent pupil becomes elliptical (Fig. 3.16a). One must attempt to maintain the alignment of the BIO parallel to the long axis of the apparent elliptical pupil in order to fit both of the examiner's pupils in the observed pupil. Sometimes it is necessary to decrease the ocular distance or use the enhanced optical convergence setting available on some BIOs to maintain pupil conjugacy ((Fig. 3.16b). Alternatively, one can obtain a monocular view by tilting the head 45° from the pupil axis so that only one visual axis enters the pupil (Fig. 3.16c).

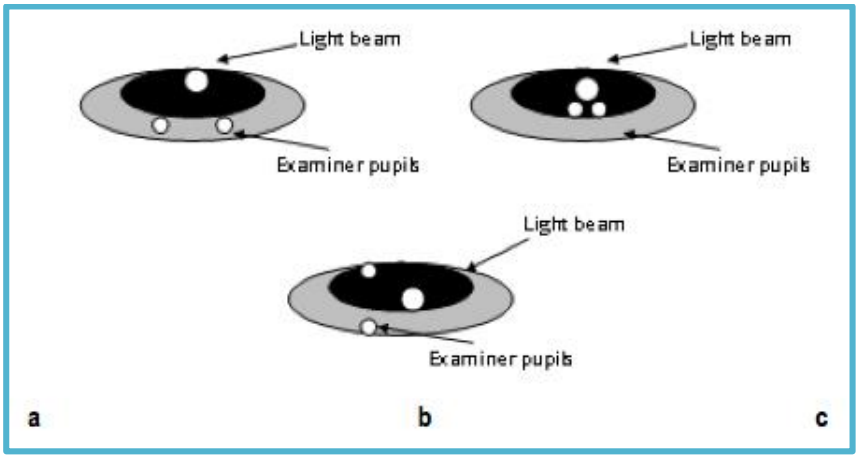

Figure 3.16: *Pupil conjugacy in peripheral views through 'elliptical' pupils*

The observation system may contain focusing lenses of +1.00 to +2.50 to reduce accommodation and allow examination of the aerial image comfortably from the 50 cm working distance. These lenses are usually only required for examiners that are presbyopic and can be replaced by plano lenses for non-presbyopic examiners.

Condensing Lenses

The condensing lenses have 3 functions: they direct the light source into the eye, generate the aerial image of the fundus and image the examiner's pupils within the patient's pupil. The lenses usually have double aspheric anti-reflective surfaces which permit clear imaging over the entire lens. One side is typically made steeper to reduce reflections and distortions from the illuminating beam. The flattest side, often indicated by a sliver ring, should face the patient during the procedure. The lenses are available clear or yellow. The yellow filter minimizes the patient's discomfort and reduces phototoxic short wavelengths, but the yellow may slightly alters the color of fundus findings. A detachable yellow filter is an available option.

The lenses are of various powers ranging from +15 D to +40D. Power adapters are available for the 20D lens (50mm) to increase field of view. The +20 D lens is used in most clinical situations (Fig. 3.17).

The magnification and field of view vary with dioptric power of the lens. For a lens of the same diameter:

↑ lens dioptric power ↓ magnification ↑ field of view

The field of view varies with the lens power but ultimately, the extent of the field of view is limited by the diameter the lens. With a 20D lens, approximately **3 full lens views** are necessary to reach the ora (Fig. 3.18). High powered lenses will facilitate viewing the ora through increased field of view.

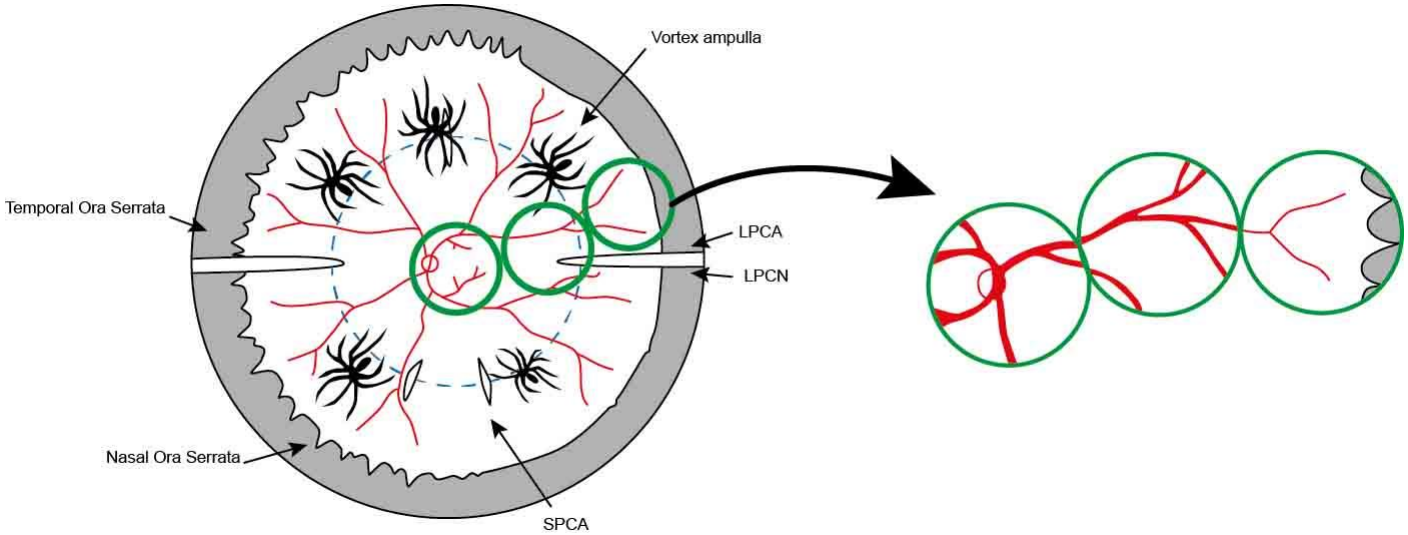

Figure 3.18: *Successive views to needed to reach the ora serrata*

The magnification produced can be approximated using the formula: **Magnification = Power of eye / Power of Lens.** Assuming the eye power to be +60D, a +20 D lens would have approximately a 3X magnification. Hence, even strong refractive errors produce minimal change in the magnification. In contrast, high refractive errors cause significant distortion in direct ophthalmoscopy.

The lens-eye focal distance is also variable with the lens power: **↑ Power ↓ Lens-eye distance (Table 3.7).**

BIO is easier to do using higher powered lenses when examining patients with small pupils, children or non-cooperative patients. This is due to the increased field of view, the reduced lens-eye focal distance and the increased converging power provided by higher power lenses. Stronger lenses, however, provide a minified image with lower stereoscopic detail.

Lens power (D)	Lens diameter (mm)	FOV (°)	Lens-eye distance (mm)
15D	52 45	36 35	60.0 60.6
20D	50 35	46 32	43.0
25D	45 33	52 38	34.1
25.5D (Pan-retinal 2.2)	52	56	34.1
28D	41	55	29.0
30D	43 31	58 42	27.0
40D	40	64	17.7

Table 3.7: *Comparison of characteristics of various BIO lenses*

Resolution and Depth of Focus

BIO offers excellent detail resolution despite the low magnification. Most beginners think that because the image is relatively minified with respect to direct ophthalmoscopy, there is a loss of resolution. However, the resolution is dependent on the optical quality and illumination of the system, not only the magnification. Magnifying a blurred image does not increase resolution. On the contrary, it provides a degraded image similar to what is seen with the direct ophthalmoscope when examining patients with high myopia. With the BIO, therefore, the examiner can distinguish incredibly fine detail even with the relative minification.

The BIO offers great depth of focus as well. Structures that are on different fundus planes will appear clear simultaneously despite their different heights. In performing direct ophthalmoscopy, focusing is required to clarify structures of different depth.

Advantages	Disadvantages
Stereoscopic view	Inverted and inversed image
Wide range of view	Low magnification
Wide panoramic field of view	Dilation required
High resolution	Difficult to master
High contrast	May be difficult to perform for examiners with back problems
Excellent depth of focus	
Independent of refractive error	
Variety of lens options	
Allows quick comparison between the eyes	
Relatively easy view through disrupted media	
Possibility of scleral depression	
Relatively short exam time	

Table 3.8: Advantages and disadvantages of BIO

PROCEDURE

Examiner Preparation

Note: Most problems with BIO arise from improper instrument set-up: excellent preparation is absolutely necessary to perform BIO adequately.

- The examiner wears his habitual refractive correction
- The instrument is placed on the head placing most of weight on the crown strap
- The crown strap is tightened and the head band is snugly but comfortably fitted so that the BIO fits like a baseball cap
- The light tower/ocular assembly is loosened using the appropriate knob and positioned at the same level and as close to the eyes as possible
- Fixating a small target at a distance of about 50cm, the monocular PD alignment is performed, by sliding each ocular, so that each eye sees the same field
- Using the vertical light alignment knob, the light source is placed in the upper 1/2 of the imaged field: this allows the illuminating light to enter the upper ½ of the pupil and the image light to emerge from the lower ½ of the pupil
- Some BIOs have a combined system which adjusts the convergence setting by default with the pupil distance setting. Where separate adjustments are possible, one should favor the setting for large pupils in order to increase stereopsis. The small pupil setting should be reserved when pupil size becomes limiting to the view.

Patient Preparation

- The patient is informed about the procedure
- The bleaching phenomenon and transient nature of vision loss is explained as well
- The pupil is dilated (see diagnostic pharmaceutical agents) to allow optimum view (a non dilated view is possible)
- The patient reclined horizontally in the ophthalmic chair (supine position) (Fig. 3.19a)
- If reclining is not possible, BIO is performed with the patient in a seated position (Fig. 3.19b)
- Reclining generally provides optimal stereoscopic views, facilitates scanning and permits scleral indentation.

Figure 3.19: *BIO with patient in seated position*

Examination Procedure

- The lens is cleaned
- The room lights are dimmed and extraneous light sources are minimized to avoid undue reflections
- The condensing lens is grasped between thumb and first finger with the white or silver line toward the patient
- The lens is held at an arm's length (50cm), the more convex surface facing towards the examiner
- The examiner stands on the right side of the patient to examine the right eye and vice versa
- The examiner moves around the patient as needed
- Examination is begun with the lens close to the patient's eye and centered on the pupil
- The free fingers of the hand holding the lens are anchored on the patient's face.
- The beam is projected into the lens at a right angle to the lens surface and the red reflex is observed
- The lens is moved slowly upward by extending the second finger which acts as a pivot on the patient's face
- The lens is moved upward keeping the pupil centered, until the fundus appears and fills the entire lens
- The free hand is used to retract the lids away from view
- The second finger of the hand with the lens may also be used to retract the lids
- The area under observation is examined
- If the image is lost, the lens is lowered towards the patient and the examiner starts the view over
- The patient is asked to change his direction of gaze; the lens may be removed from the light path to ensure the patient complies with instructions
- The procedure is repeated
- The procedure is started at 12 o'clock and the examiner proceeds in a clockwise manner examining 8 directions of gaze in a systematic way
- The examiner keeps his head positioned 180° away from the observed area
- In order to maximize stereopsis, the examiner should aim to keep his pupils parallel to the long axis of the patient's apparent elliptical pupil in peripheral views
- In each direction, the examiner "rocks" his body so that a view of the retina is obtained from the ora to the posterior pole (i.e., scanned). The light beam must stay perpendicular to the lens surface during this scanning process
- The posterior pole is assessed last when the patient is slightly more light adapted
- The light is kept on the same fundus area for a maximum of 40 sec. (ANSI recommendation).

Tips for Success

- Practice! Practice! Practice! BIO is one of the most difficult procedures to master
- Know the retinal **landmarks**
- Always start with the right eye
- The viewing distance (~50cm) must be kept constant - beginners have a tendency to move in closer
- Ambidexterity is ideal, but the same hand can be used if the examiner revolves around the patient as needed
- The examiner keeps his eyes, oculars, condensing lens and examined fundus on a **"locked" common axis**.
- The examiner moves his torso to perform scanning movements, **not** his head bending sideways
- The lens is kept perpendicular to his viewing axis, not parallel to the patient's pupil
- Reflections are minimized by slightly tilting the lens very slightly from its perpendicular alignment
- "Crescent shadows" at the edge of the lens are eliminated in the lens by tipping the lens toward the side of the shadow
- The lens' focal distance (eye-lens distance) is respected to maximize the field of view
- Remember the inversed and inverted nature of the **image and the motion** of fundus findings
    - In order to properly understand what is observed and correctly record it, the examiner should imagine himself standing feet up on the ora viewing back into the eye (Fig. 3.22)
    - The examiner must move his head towards a finding to move it more centrally in the lens

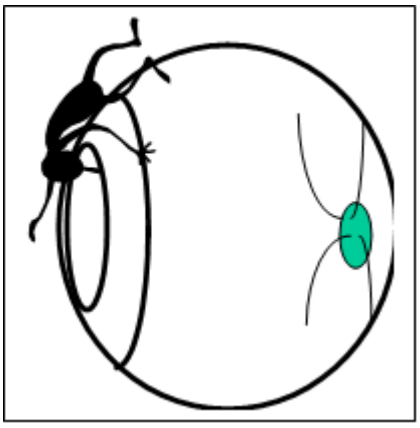

Figure 3.22 Viewing the retina with BIO

- Remember that the image formed of the retina is reversed and inverted; the area examined is not opposite to your viewing position. i.e., the direction of the patient's gaze is the area of the fundus under examination. If the patient is looking inferior nasal then the examiner is looking at inferior nasal retina
- The view can be maximized with the examiner positioning his head 180° from patient's direction of gaze
- If the patient's facial anatomy (e.g. nose or eyebrow) is in the way when trying to examine a given area of the retina, have the patient turn the head in the opposite direction while maintaining the gaze position
- The examiner should allow blinks. If these are excessive, instead of releasing the lid grip, the examiner may open and close the patient's eye
- Minor sideways lens movements may be needed to negotiate media opacities.

Distorted/blurry view	• Condensing lens upside down • Dirty lens • Examiner distance not optimal to view the image of the retina, especially important for examiners with presbyopia • Uncorrected refractive error (examiner) • Improper "common axis" alignment • Oblique astigmatism in far peripheral view • Inability to change accommodation for (+) ocular lenses
Reflections	• Condensing lens upside down • Dirty lens • Lens perfectly perpendicular to line of sight
Diplopia	• Incorrect PD setting • Examiner distance too close • Impaired fusional ability • Tilted BIO (horizontal misalignment)
Poor stereopsis	• Incorrect PD • Poor dilation
Incomplete image in the lens	• Lens-eye distance too close or too far • Improper "common axis" alignment • Lens-eye distance too close or too far • Improper "common axis" alignment • Illumination angled improperly • Poor dilation • Peripheral view with small apparent elliptical pupil • Light spot too small or too focused
Uncooperative patient	• Illumination too bright • Involuntary eye movements • Poor assigning of fixation target by the examiner • One eye closed • Restricting blinks • Poor instructions by the examiner! • Poor patient gaze control by the examiner!

Table 3.8: *Trouble-Shooting*

RECORDING/DRAWING LESIONS

Since the view obtained with BIO is inverted and reversed, documenting observed findings can be difficult at first. You can reverse and invert the image in your mind before documenting it but it is a difficult method for many. Alternatively, one can ease the drawing of lesions using the following method. Invert the fundus diagram with the 12:00 position towards the feet of the patient. The lesion is then drawn **as seen** in the **opposite** quadrant of where it is perceived (Fig. 3.23).

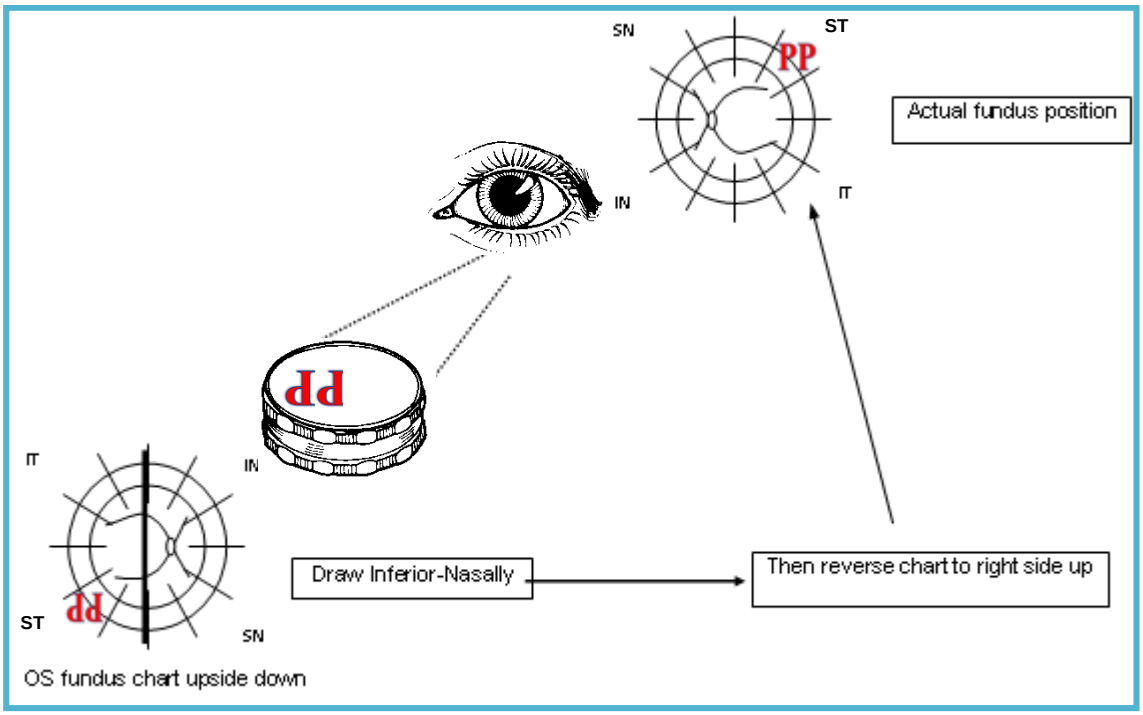

Figure 3.23: *Drawing fundus lesions*

LENS CLEANING

Both fundus biomicroscopy lenses, BIO lenses, BIO oculars and contact devices should be treated with care to maintain the optical quality and integrity of the anti-reflect coatings. Dry clothes or tissues should **not** be used to wipe the lenses. They should be washed with warm water and a mild non-abrasive detergent such as hand soap, photographic lens soap or even a contact lens cleaning solution. They should then be rinsed with warm water and dried with a soft lint-free cloth. Some lens distributors provide their own lens cleaners.

Should disinfection be necessary, avoid the use of alcohol wipes, acetone or peroxide which can damage the anti-reflective coatings. Soak the devices in a 1:10 part bleach/distilled water solution or a 3% hydrogen peroxide for 10 minutes (longer than 10 minutes exposure can damage some of the components). Some manufacturers also recommend the use of 2% gluteraldehyde aqueous solution.

MONOCULAR INDIRECT OPHTHALMOSCOPY

DESCRIPTION (FIG. 3.24)

The monocular indirect ophthalmoscopy (MIO) is a method used for ocular fundus examination which employs optical principles that are somewhat similar to those of the BIO. While it provides monocular viewing, MIO is useful in that it provides a wider field of view than the direct ophthalmoscope and is easier to use than the BIO especially with non-dilated pupils. Given its limited range of view and lack of stereoscopy, MIO is rarely used in comparison to BIO. However, it may still be preferred in instances where pupil dilation is not possible.

THEORY AND INSTRUMENTATION

Two methods of performing MIO exist. One uses the direct ophthalmoscope in combination with a condensing lens (usually a +20D) to create the indirect optical setting. The other uses an actual instrument built with the optics to produce the desired indirect ophthalmoscopy setting. The instrument provides better optics and imaging than the direct ophthalmoscopy (DO)-lens scheme. While MIO is in general rarely used, the relatively recent Panoptic from Welsch Allyn has gained some popularity.

Figure 3.24: *Monocular indirect ophthalmoscope*

The MIO principle is somewhat similar to the BIO. A condensing lens system is used to image a light source on the fundus and to form a **real aerial image** which is then examined using an observing lens system, either the lenses in the direct ophthalmoscope or the eyepiece objective in the MIO device. When the direct ophthalmoscope method is used, an inverted and reversed image is created. With the Panoptic and other MIO devices, an additional set of relay lens system inverses and reverses the image to present is as an erect image.

Advantages	Disadvantages
Panoramic field of view	Limited field of view compared to BIO
Dilation of pupil not necessary	Full retinal examination not possible
Erect image (with devices)	No stereopsis
Relatively magnified image	
Easy to learn	
Quick method	

Table 3.9: *Advantages and Disadvantages of MIO*

PROCEDURE

With Panoptic instrument

- The examiner removes his eyeglasses (optional)
- Use the focusing wheel on the instrument to focus an object 3 to 5 meters away
- Set the aperture dial to small
- Turn the instrument on using the rheostat on the handle
- The patient is seated, educated and asked to fixate a distant target
- Seated in front and at level to the patient, place the instrument approximately 10-15 cm. away from the patient's eye
- Position the instrument 10-15 degrees to the temple side of the examined eye, so as not to obstruct the other eye's fixation (Fig. 3.26).

Figure 3.26: *Position of patient and examiner during MIO*

- Look and center for the red fundus reflex through the device
- Move in towards the patient keeping the reflex in view until the eye cup sits on the patient's orbital rim
- Adjust the focus to sharpen the fundus view
- Adjust the diameter of the light source to maximize the view
- Proceed with the fundus examination as one would in with a direct ophthalmoscope.

With DO and Condensing Lens

- The same set-up as above is followed
- A condensing lens (usually a+20D) is placed at its focal length (~5 cm) in front of the eye
- The direct ophthalmoscope is held at a working distance of approximately 20 to 30 cm
- The appropriate lens is dialed in the DO to view the red reflex and clear the fundus image.

FUNDUS LANDMARKS

ORIENTATION

In order to examine and document findings of the peripheral retina, a method of orientation & representation of the fundus as a whole is necessary. The fundus is traditionally depicted on a circular flat surface that is divided into 3 sections that are based on several anatomical structures used to demarcate certain regions:

1. **Posterior Pole**: Area delimited by the ONH & the major superior and inferior vascular arcades (~6mm)
2. **Mid – Periphery**: Area between superior & inferior vascular arcades and the equator
3. **Periphery**: Area from the equator to & slightly beyond the ora serrata (~ 5mm)

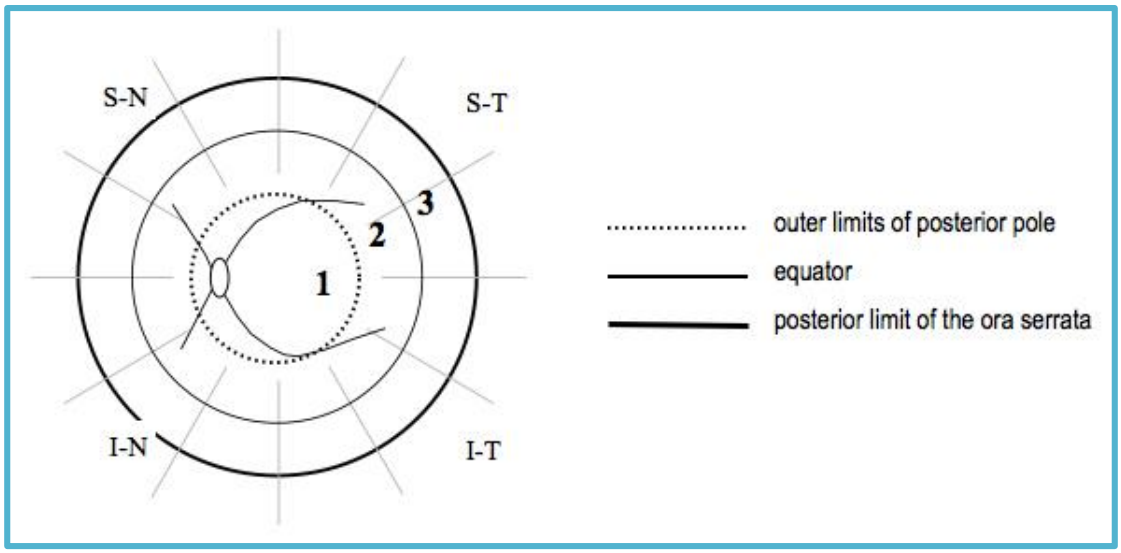

Figure 3.27: *Schematic division of the fundus*

In illustrating the spherical eye onto a flat surface, one must accept that certain distortions are created. The disc & macula are relatively minified while the equator, peripheral retina & ora are magnified. Therefore, on the diagram, the ora appears larger than the equator but is not so in reality. The equator is the largest circumference of the eye.

For location purposes, the eye is divided further into 4 quadrants centered on the fovea. One can also refer to an imaginary clock face centered on the fovea with the 12 o'clock position superiorly. The terms inner & outer are used to denote location with respect to the center of the globe. Anything closer to the center of the globe is "inner" compared to anything further from it. Finally, the Disc Diameter unit (1DD ~ 1.5mm) is used to indicate the size & location of lesions with respect to the Optic Disc.

ANATOMICAL LANDMARKS

Vortex Vein Ampullae

The Vortex Vein Ampullae are collecting channels for the multiple thin curved venous tributaries that cover most of the fundus. They are usually 4 (1 per quadrant) but can be fewer, or as many as 10-15. They are located around the equator & mark the equatorial region but they are not always visible. They are red-orange, octopus-shaped & are commonly found with significant surrounding pigmentation (RPE hyperplasia). The vortex ampullae drain into vortex veins going through the sclera posteriorly.

Long Posterior Ciliary Arteries & Nerves (LPCA & LPCN)

The LPCA & Nerves appear as 2 straight lines typically white to yellowish with pigmented borders. They run in the supra-choroidal space stretching from the Ora to the Equator at the 3 & 9 o'clock positions & divide the retina into superior & inferior halves. The artery usually runs below the nerve temporally & above the nerve nasally. The nerves are usually more visible than the arteries.

Short Posterior Ciliary Arteries & Nerves

The SPCA & Nerves are short, straight white to yellowish lines with pigmented borders found in the peripheral retina. They are 10 to 20 in number but usually only 4 to 8 are visible. They extend from the mid-periphery to the periphery usually congregating near the vertical meridian but they can be scattered anywhere. They are not as consistently visible as the LPCA & LPCN.

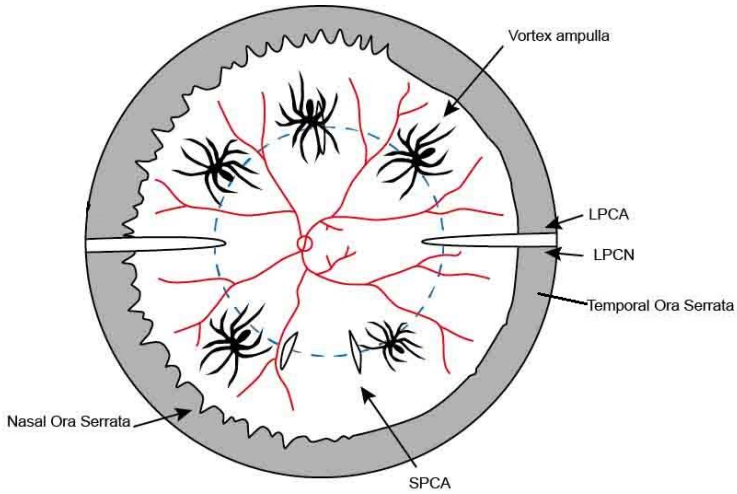

Figure 3.28: *Schematic division of the fundus*

Inspired by: Bell FC., Stenstrom WJ. Atlas of the Peripheral Retina, W.B. Saunders Company, 1983.

Peripheral Vessels

The peripheral arteries & veins run parallel to the ora serrata & come to 1.5mm from the Ora serrata. As a result, a 1.5mm capillary free band exists posterior to the edge of the Ora serrata.

Ora Serrata

The Ora serrata represents the anterior limit of the neural seeing retina. It is a 360° junctional band that is more narrow temporally (~1mm) than nasally (~2mm). It is scalloped (nasally > temporally) with 20 to 30 dentate processes per eye. The brown rounded areas that extend posteriorly from the Ora are called Oral Bays while the whitish anterior retinal extensions into the bays are called Oral Teeth.

Pars Plana

The Pars Plana is a 4-5 mm region that extends from the ora serrata to the ciliary processes (60-70/ eye). It is composed of an inner non-pigmented epithelium & outer pigmented epithelium. The Pars Plana is chocolate color. The ciliary processes are also brown in reality but appear cream color during ophthalmoscopy because of the tangential illumination used to see them.

Vitreous

The vitreous is not truly a major anatomic landmark since it is usually invisible but is included here because of the prominent role it plays in the appearance & development of peripheral findings. One must understand the close vitreo-retinal relationships that exists throughout the fundus which may be altered during the development of peripheral lesions or which may themselves cause the formation of peripheral retinal anomalies.

The vitreous is a type of gel, semi-solid to liquid in consistency, made up of 99% water, 1% hyaluronic acid, to allow maximum light transmission. It occupies 67-75% of the ocular volume. It is clear & usually retains its clarity through most of a person's life. Vitreous strands & floaters which are debris of vitreous material are relatively common & may be seen ophthalmoscopically.

The vitreous is attached at several locations in the eye. It is attached strongly at the posterior lens surface in young persons, a fact that renders the extraction of cataracts difficult in the young. It is attached at the vitreous base with a strong 2-4 mm connection that straddles the Ora serrata & holds the vitreous cortex, sensory retina & pars plana together. It is attached at the ONH Margin with a strong ring-form attachment that is observable as the "Weiss ring" following PVD. Finally it is weakly attached at the Macula & peripheral retinal vessels.

Vitreous Base (VB)

The vitreous base, while usually not visible, is also considered a landmark. The VB is a 2-4 mm band that straddles the Ora & represents the limit between anterior & posterior vitreous cortex. The anterior limit is sometimes visible as a whitish linear haze on & parallel to the pars plana. The posterior limit is usually invisible unless it is protuberant or altered by severe vitreous traction in which case it is called a prominent VB. A prominent VB looks like a thin elevated white line parallel to the Ora. The VB is the most adherent vitreal attachment. Its limits can sometimes be denoted by the increased pigmentation that results from RPE hyperplasia at its limits.