Instruments for ocular examination

part one: the ophthalmoscope

by Andrew Cripps FBDO (Hons) PG Cert HE FHEA

Competencies covered:
Dispensing opticians: Ocular examination
Optometrists: Ocular examination

In 1848 Charles Babbage recognised that it was possible to provide illumination inside the eye, and a means of viewing what has been illuminated, by the laws of reflection. The German physicist Hermann von Helmholtz is credited with re-inventing what became known as the ophthalmoscope in 1851.

In order to view the fundus four conditions need to de fulfilled:
- There must be adequate illumination of the posterior chamber as there is no natural source of light available.
- Having illuminated the fundus, light must have an uninterrupted passage leaving the eye through the pupil.
- Emergent light must be detected by the observer's eye.
- An optical system is required to focus the emergent light on the observer's retina.

These conditions can be met in two ways which are termed *direct ophthalmoscopy* and *indirect ophthalmoscopy*.

The direct ophthalmoscope

Figure 1 shows the optical principles for a hand-held ophthalmoscope that also provides illumination. The vergence of light emitted from a small source is made parallel by the condenser lens. It then passes through an aperture stop and reaches the field lens. The distance from the field lens to the mirror is almost the same as from the mirror to the subject's retina and these are called conjugate distances. The field lens forms an image of the source at the mirror and ideally, this image will be positioned at the eye's anterior focal point. However, in practical terms it is usually at a slightly greater distance so that light will converge towards the subject's retina. The size of the patch of light on the fundus will depend on several factors:
- The diameter of the pupil
- The size of the source of light
- The distance of the image formed at the mirror from the eye

Modern instruments usually have several stops which provide improved viewing in different circumstances. A large aperture gives a relatively wide field for general observation of the fundus. A smaller stop is preferred where the pupil is small and where small areas are to be viewed. If the stop is reduced further permitting only a narrow beam, a clearer view of the macula can be obtained. A green filter is often added to reduce red light which gives more contrast when observing retinal blood vessels. Other extras may include a slit stop to help identify elevations and depressions and a cross in green light for the detection of eccentric fixation.

Assuming that the observer's eye and the viewing aperture are very close, a viewing lens will be required so that

abdo|CET

This article has been approved for 1 CET point by the GOC. It is open to all FBDO members, including associate member optometrists. The multiple-choice questions (MCQs) for this month's CET are available on **page 8** and **online**. Insert your answers to the six MCQs on the inserted sheet or online at www.abdo.org.uk. After log-in, go to 'CET Online'. Please ensure that your email address and GOC number are up-to-date. The pass mark is 60 per cent. The answers will appear in the November issue of *Dispensing Optics*. The closing date is 17 October 2013.

C-32176

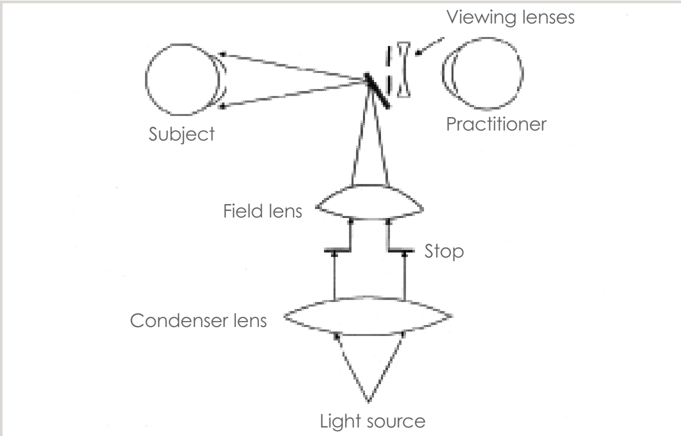

Figure 1: The direct ophthalmoscope

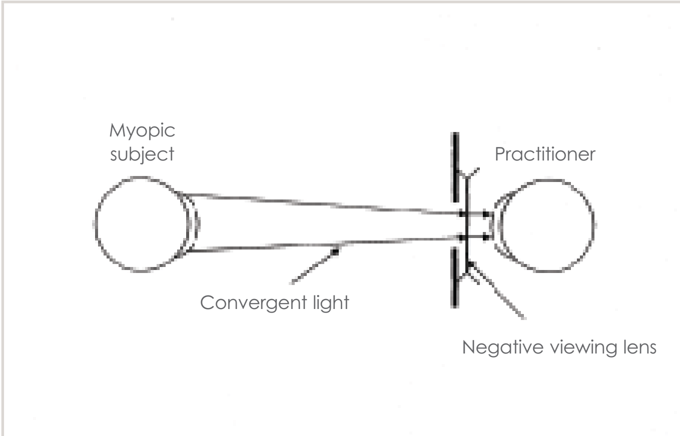

Figure 2: Observation through a viewing lens

light from the fundus can be seen clearly. These viewing lenses range from very high plus to very high minus powers and are usually housed in a moveable train so that a specific power can be selected by rotating a selection wheel. **Figure 2** shows the situation where a myopic eye is observed by an emmetropic eye. Light from the myopic eye will be converging towards the viewing aperture so an emmetropic practitioner will need to select a high minus viewing lens in order to see the image clearly. The actual power of the lens selected will depend on the distance between the subject's eye and the viewing aperture, the degree of the subject's refractive error and that of the observer.

Having the same optical system for illumination and observation is a neat solution but does introduce problems, mainly the troublesome reflections of the anterior corneal surface which will be very noticeable to the observer. When light is incident on a surface separating two different optical media some will be reflected. The brightness of the reflection will depend on the refractivity across the surface boundary. At the anterior corneal surface refractivity will be far greater than for the other ocular interfaces and so the reflection will be much brighter. This can be reduced to some extent if the observer's viewing aperture is above the mirror as the viewing axis and the illuminating axis will no longer be coincident. A smaller stop also reduces the problem, as does the use of polarised light with an analyser to absorb light which has been reflected from the cornea.

Field of view and magnification

In common with most optical instruments, as the magnification increases the field of view reduces and, of course, the opposite is also true. In general, slightly more of the fundus will be visible in hypermetropia than in myopia.

The linear field of view of the fundus can be calculated from the expression

$$z = p/d \times (1+dK)/(K + Fe)$$

where **z** is the linear field of view, ***p*** is the pupil diameter, ***d*** is the viewing distance, ***K*** is the ocular refraction and ***Fe*** is the power of the eye. If the pupil diameter is 4mm, the viewing distance 25mm and Fe +60, the following values will result:

Ocular refraction (K)	Linear field of view (z)
+10.00	2.857mm
+5.00	2.769mm
0	2.667mm
-5.00	2.545mm
-10.00	2.400mm

Table 1: Linear field in myopia and hypermetropia

If the distance from the subject to the viewing aperture varies, magnification will only change slightly whereas the field of view expands considerably if the viewing distance is reduced. It is therefore always an advantage to keep the viewing distance to a minimum. If a stereoscopic view of the retina with high magnification and excellent resolution is required it is possible to use a slit lamp and auxiliary lens such as the Hruby lens. This has a power of -55.00D in order to neutralise the power of the cornea and maintains a direct view of an upright, virtual image. The slit lamp must be set up for the practitioner's personal use with the magnification at its lowest setting. The illumination of the slit lamp should be adjusted for an intermediate slit height and a 2mm width, and then placed in the straight ahead position. Once the slit-lamp is moved into position so that the slit is imaged in the patient's pupil, the Hruby lens is placed as close as possible in front of the patient's eye. Direct ophthalmoscopy using a slit lamp and auxiliary lens in this way can provide a very high level of magnification, the actual level of magnification depending on what is available via the slit lamp. Stereopsis is provided to a greater degree than all other examination techniques. However, the field of view is smaller than all other examination methods with the exception of direct monocular ophthalmoscopy. Also, the quality of the image is easily affected by opacities in the transparent media. Because the magnification is so high, small movements can easily affect the quality of the image.

Using the instrument

Subdued lighting should be used, just sufficient for the subject to be able to fixate on a target. The subject's pupil will then be dilated allowing greater visibility of the fundus. The subject should be asked to view a large target positioned about 45 degrees above the horizontal midline. This provides a comfortable stance for the optometrist

Continued overleaf

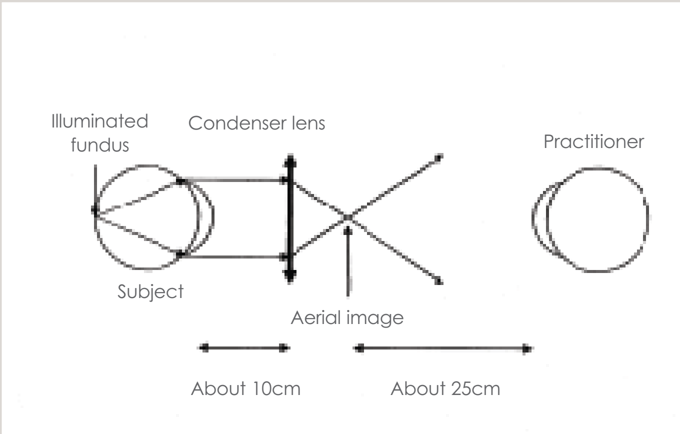

Figure 3: Principle of indirect ophthalmoscopy

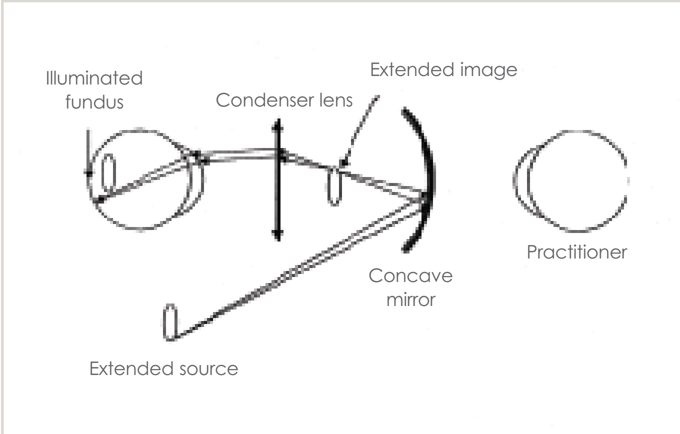

Figure 4: Illumination of the fundus in indirect ophthalmoscopy

throughout the examination. Initially, a large diameter aperture is used to look around the external features of the eye including lashes, lid margins, palpebral conjunctiva, sclera, the colour of the iris and the size and shape of the pupil. The subject then keeps the eye still while the practitioner moves around to scan the fundus. Examination of the peripheral fundus requires the subject to look in the eight cardinal directions to allow an adequate sweep of the peripheral fundus. The viewing lens will need to be changed when the subject (or the optometrist) has a refractive error, and when the media is to be examined. A smaller stop is useful for observation of the optic disc and retinal vessels as it tends to reduce the unwanted bright corneal reflex. The smallest stop is best for viewing the macula for the same reason.

The indirect ophthalmoscope

This is another method of observation where light from an illuminated fundus leaves the eye and a separate condenser lens is used to view the inverted image formed in air. This method has the advantage of enabling a larger area of the fundus to be viewed. **Figure 3** shows the position of the condenser lens and the image formed.

In practice, the condenser lens is usually a Volk lens varying in power between +13.00D and +30.00D, held about 1cm from the eye. These lenses are symmetrically biconvex and can be used either way round. They have aspherical surfaces which reduce spherical aberration and are multi anti-reflection coated.

Figure 4 shows how the fundus is illuminated. An extended light source reflects light from a concave mirror, forming an extended image. Light from this image is then refracted by the condenser or Volk lens, enters the eye and forms a light patch on the retina. The actual focus will be just in front of the retina so as not to interfere with the aerial image of the fundus. The light source is often contained in a headband worn by the practitioner. Handheld indirect ophthalmoscopes are also available although the basic optical principles are much the same (fundus illumination and observation).

In general, the direct method provides considerably more magnification, the field extent being about the diameter of the optic disc and the image erect. The indirect method produces a field about five times that of the direct method and the handheld condenser forms an inverted image.

A stereoscopic view, enabling better assessment of the relief of the optic disc and its related blood vessels, is only possible with an indirect system and there is less light scatter from media opacities. With the exception of handheld indirect instruments, the direct system is generally easier to use.

Figure 5: The normal fundus

Observations

The purpose of ophthalmoscopy is to illuminate the fundus so that a series of structures previously unseen can be examined and any irregularities noted. The experienced observer is able to compare the view obtained of the fundus with what is considered to be a "normal" fundus, ie one without significant abnormalities. The skill here is in determining what is physiological and what is pathological. **Figure 5** shows what is regarded as a normal fundus.

The observer will be looking at retinal blood vessels, the optic disc, the macula in detail and peripheral regions of the retina for any abnormalities.

By viewing along a blood vessel and its various branches, the optic disc can be located. The colour of the disc and its margins and the cup if there is one are all noted as well as the presence of any pigment, choroidal or scleral crescents around the disc. Retinal blood vessels are examined in each quadrant, the veins appearing relatively large and dark red, whilst the arteries are relatively thin and pale. Irregularities can indicate or help to confirm high blood pressure, diabetes, glaucoma and other potentially sight-threatening diseases.

MCQs overleaf

Any opacities in the crystalline lens, cornea, aqueous or vitreous can be seen as any opaque body in the path of rays reflected from the fundus will appear black and therefore suspicious.

The ophthalmoscope, whether direct or indirect, is an indispensable instrument in the practitioner's consulting room. The basic principles have been developed widely by various manufacturers to provide instruments easier and quicker to use but, as with most scientific instruments, it is the expert interpretation of what is viewed that is most important.

Suggested sources for more information:

Tunnacliffe AH. *Introduction to Visual Optics*. 4th Ed. London : ABDO, 1993;Ch 5.
Volk Optical website http://www.volk.com/pdf/volkcatalog.pdf
Welch Allyn website www.welchallyn.com
Field A and Barnard S. Slit Lamp Indirect Ophthalmoscopy. [online] 2002. Available at www.academy.org.uk/tutorials/volklens.htm (Accessed 11 June 2013)

Andrew Cripps is a dispensing optician based in Suffolk. He is an examiner for ABDO and the WCSM and has contributed a number of articles for CET. He is a member of the Continuing Education Review Panel and has lectured in the UK and abroad. Andrew was a senior lecturer in ophthalmic dispensing at Anglia Ruskin University. He is a member of the GOC Fitness to Practise panel. ■

Multiple choice questions (MCQs)

Instruments for ocular examination

part one: the ophthalmoscope

1. In direct ophthalmoscopy the function of the condenser lens is to . . .
a. ensure refracted light has zero vergence
b. focus incident light on the aperture stop
c. direct light onto the concave mirror
d. enable a wider view of the fundus

2. Indirect ophthalmoscopy produces a field of view. . .
a. where the image is virtual and erect
b. expanded by reflection at a concave mirror
c. which is dependent on the position of the condenser lens
d. about the diameter of 5 optic discs

3. In ophthalmoscopy reflections from the anterior surface of the cornea can be a nuisance because . . .
a. they will be focused in the same plane as the inverted image formed by the condenser lens
b. the beam cannot be stopped down when viewing the macula
c. the same optical system is used for illumination and viewing
d. refractivity is less than at the other transparent boundaries

4. When using a slit lamp and high-powered auxiliary lens to view the fundus, which statement is true?
a. The clarity of the image will not be affected by media opacities
b. The field of view obtained is less than for most other methods
c. Magnification is restricted by the field lens
d. The auxiliary lens should be placed at about 10cm from the subject's eye

5. In direct ophthalmoscopy, the power of the chosen viewing lens will depend on . . .
a. the distance from the sight hole to the patient's eye
b. the size of the pupil relative to the extent of the fundus to be viewed
c. how much magnification is required
d. whether the fundus or transparent media is being observed

6. In optical instruments such as the ophthalmoscope . . .
a. images are always virtual and upright
b. as magnification decreases the field of view increases
c. illumination must be provided internally

The deadline for posted or faxed response is 17 November 2013 to the address on page 4.
The module code is C-32176

Online completion - www.abdo.org.uk - after member log-in go to 'CET online'

After the closing date, the answers can be viewed on the 'CET Online' page of www.abdo.org.uk. To download, print or save your results letter, go to 'View your CET record'. If you would prefer to receive a posted results letter, contact the CET Office 01206 734155 or email cet@abdo.org.uk

Occasionally, printing errors are spotted after the journal has gone to print. Notifications can be viewed at www.abdo.org.uk on the CET Online page