1 Introduction

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In this book the fundamental approach is to describe the classification of diabetes, risk factors for diabetic retinopathy and lesions of diabetic retinopathy, and explain the significance of these lesions in terms of progression of the disease, recommended treatment and consequences to vision. Methods of screening for diabetic retinopathy and other retinal conditions that are more frequent in diabetes, or have similar appearances to diabetic retinopathy, are also discussed.

The four main themes in this introductory chapter are: (1) practical assessment consisting of history and examination; (2) multidisciplinary management; (3) investigative techniques to assess diabetic retinopathy; and (4) the use of lasers in diabetic retinopathy.

PRACTICAL ASSESSMENT

History

The history of the patient can be divided into the following sections: presenting complaint; past ocular history; diabetic history; past medical history; family history; drug history; and psychosocial history.

Presenting complaint

Many patients with diabetic retinopathy are asymptomatic until the more advanced stages of the disease. When symptoms do occur they are usually a gradual blurring of vision in diabetic maculopathy and a sudden onset of visual symptoms with a vitreous haemorrhage. Patients notice a streak or a sudden onset of floaters in one eye, which increases with progressive visual loss over the next hour as the vitreous haemorrhage progresses. The amount of visual loss depends on the amount or position of the vitreous haemorrhage. If the vitreous or preretinal haemorrhage is in the visual axis of the eye, then visual loss is usually quite marked.

Past ocular history

The past ocular history of patients covers: (1) visual symptoms; (2) cataract or strabismus surgery; (3) laser treatment; and (4) vitrectomy.

Diabetic history

The diabetic history of a patient includes: (1) type of diabetes; (2) duration of diabetes; and (3) treatment of diabetes (e.g. diet, oral hypoglycaemics, insulin or a combination).

Complications of diabetes

The complications of diabetes can fall within three categories: (1) nephropathy (renal impairment, peritoneal dialysis, haemodialysis); (2) cardiovascular (angina, myocardial infarction, coronary artery bypass); and (3) cerebrovascular (transient ischaemic attack, stroke).

Past medical history

Past medical history can include serious illnesses and operations.

Drug history

Patients should disclose drug history such as present medication and any allergies.

Family history

Any history of diabetes or other illnesses in the family should be discussed.

Psychosocial

The patient's physosocial factors, such as occupation, number of cigarettes smoked per day, units of alcohol consumed per day, history of psychiatric illness and home circumstances (e.g. type of accommodation, whether lives alone, etc.), must be considered.

A Practical Manual of Diabetic Retinopathy Management, Second Edition.
Edited by Peter Scanlon, Ahmed Sallam, and Peter van Wijngaarden.

Companion Website: www.wiley.com/go/scanlon/diabetic_retinopathy

Eye examination

Assessment of visual acuity

The first part of the eye examination is an assessment of visual acuity (VA). A Snellen or LogMar chart is used and should be back surface illuminated in order to provide accurate measurements (see Figs 1.1 and 1.2).

The unaided VA is recorded first. The VA with current distance spectacle correction is then recorded. Finally, the VA with current distance spectacle correction and a pinhole is recorded. The best of these three measurements is recorded as the best corrected visual acuity. A refraction may be performed if required.

Assessment of colour vision

People with diabetes can develop an acquired colour vision defect (typically a blue loss initially) prior to showing any significant features of diabetic retinopathy. I have seen one patient who appeared to have mild non-proliferative diabetic retinopathy who had developed pronounced loss of colour vision; this meant that he was unable to continue in his current employment as a train driver.

The most appropriate test for identifying and quantifying acquired colour vision loss is the Farnsworth-Munsell 100 hue discrimination test (see Fig. 1.3). In clinical practice, however, this test is often not available and the Ishihara test, which is designed for detecting congenital (red/green) colour vision defects, is applied. If the Ishihara test is used for the assessment of acquired colour vision defects, clinicians need to be cautious when interpreting test results since it produces a high false-negative rate; passing the test is not necessarily consistent with normal colour vision.

Inspection of external structures

An inspection of external structures includes comparing one eye with the other to detect unilateral abnormalities and to determine whether the opening between the lids is symmetrical. The margins of the eyelids are inspected for ingrowing eye lashes, inversion or eversion, mucus, discharge, scales or lumps. The conjunctival lining is inspected in each eye and the area over the lacrimal sac at the medial corner of the lower lids and nose on each side.

Visual fields to confrontation

The patient must cover one eye and stare at the examiner's eye. The examiner's finger/hand or an object such as a hat pin with a white or coloured head will then be moved out of the patient's visual field and be brought back in, and the patient asked to indicate when the finger/hand

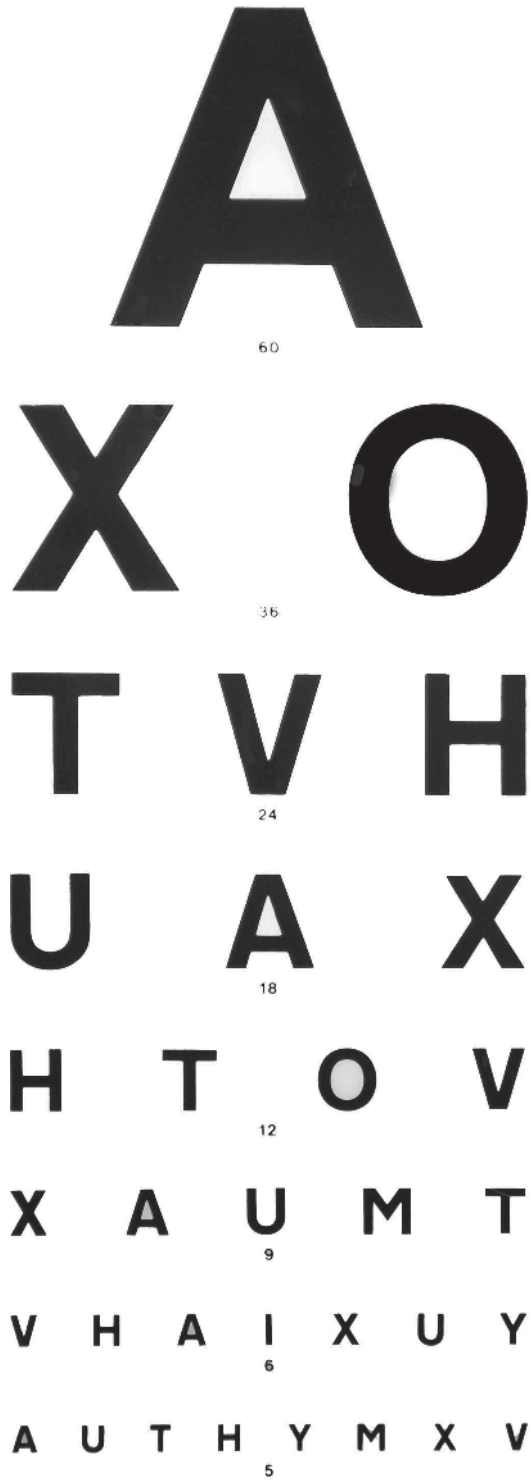


Fig. 1.1 Snellen visual acuity chart.

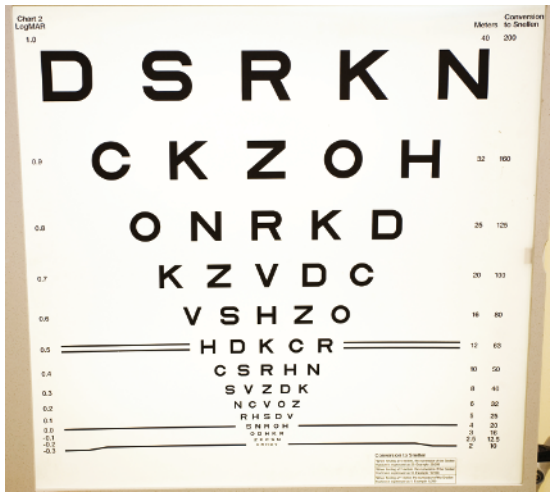


Fig. 1.2 LogMar visual acuity chart.

or object comes back into view. This can be used as a simple preliminary test and can be useful particularly if a hemianopia is suspected. More minor degrees of field loss usually require formal testing using automated perimetry or a tangent screen examination.

Ocular movement

Patients with diabetes do develop nerve palsies that affect ocular movement, but this is usually apparent from the history of sudden onset of diplopia.

Pupillary reactions to light and accommodation

The pupils should be inspected to check that they are equal in size and shape and that they react equally to light and accommodation.

Red reflex with an ophthalmoscope

This helps to determine if a media opacity is present, for example, a cataract or vitreous haemorrhage.

Slit-lamp biomicroscopy of the eye

1. **Check that a clear binocular image of the slit beam can be obtained.** First check that clear monocular images can be obtained from each eyepiece. A frequent cause of blurred vision is that the previous operator may have left these eyepieces at an unusual focus. The eyepiece construction allows for the distance between both eyepieces to be modified to reflect the interpupillary distance of the user. A sharply defined single image of the slit should be seen.
2. **Patient instructions and positioning.** Clear instructions need to be given to the patient and the patient needs to be comfortable. This may require: adjusting the patient height; adjusting the height of the chin rest so that the outer canthus of the patient's eye is aligned with the marker; ensure that the patient's head is central; and a fixation target may be used for the eye not being examined.
3. **Illumination.** Controlling the light levels falling on the eye is also an important part of any slit-lamp routine. This can be achieved by altering the power, adding a filter or altering the slit width and height.
4. **Magnification level.** The magnification can be adjusted depending on the type of slit lamp used.

Routinely undertaken examinations

Examination of the following structures is routinely undertaken: (1) lids and lashes; (2) conjunctiva, cornea and sclera; (3) tear film assessment; (4) anterior chamber; (5) iris (it is important in diabetic retinopathy to check the iris for rubeosis); and (6) lens (a cataract is more common in people with diabetes).

Intraocular pressure

Measurement of intraocular pressure is often undertaken using the Goldmann tonometer.

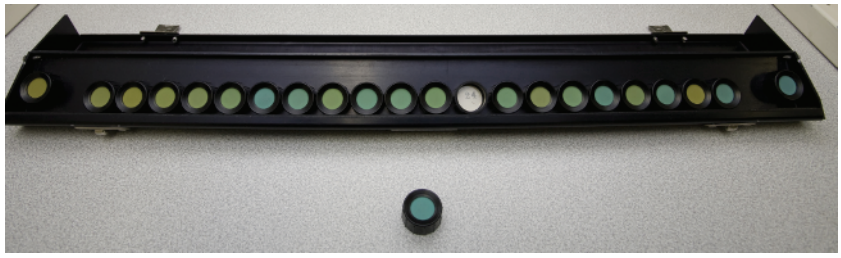


Fig. 1.3 Farnsworth-Munsell 100 hue discrimination test.

Pupil dilation

Both pupils are dilated with G Tropicamide 1% and, in most patients, also G Phenylephrine 2.5%.

Direct ophthalmoscopy

Direct ophthalmoscopy is an examination method which is commonly used by physicians and general practitioners. It provides magnified views of retinal details such as the optic disc, individual retinal vessels and the fovea. It is fast and easy to perform and images appear upright and in normal orientation. It has a limited two-dimensional (2D) field of view and has been shown to have a limited sensitivity and specificity for the detection of sight-threatening diabetic retinopathy. It is, however, useful for ad hoc detection of diabetic retinopathy (see Fig. 1.4).

Slit-lamp biomicroscopy of the retina

Slit-lamp biomicroscopy is the most common method employed by ophthalmologists to diagnose and monitor retinal disease. A well-dilated pupil is very important for obtaining an adequate view of the posterior segment with the slit-lamp biomicroscope. Several condensing lenses enable the desired magnification to be achieved. These lenses fall into two categories.

1. **Non-contact lenses**, such as the 60D, 78D and 90D, provide a magnified stereoscopic view and an inverted, reversed image of the retina. The 60D lens provides the most magnification, with the 78D lens providing less and the 90D lens providing the least magnification. The reverse is true with respect to field of view, however; the 90D lens provides the most, the 78D lens provides less and the 60D lens provides the least. Newer lenses have been produced which the manufacturers claim to have a higher magnification without sacrificing much of the visual field view (e.g. Superfield NC, Digital Wide Field and the Digital 1.0x imaging lenses provided by Volk; see Fig. 1.5).
2. **Fundus contact lenses (contact lens biomicrosopy)** are used if thickening or oedema is suspected (which is not obvious when using the non-contact lenses; see Fig. 1.6). The Goldmann three- or four-mirror lenses and the contact ruby lens are commonly used fundus contact lenses that provide images at the same orientation as the retina. Lenses commonly used for laser such as the Volk Area Centralis and the Ocular Mainster (Standard) focal/grid lens provide an inverted image.

For scanning the retina, moderate illumination and a wider slit-lamp beam are used. For evaluating retinal thickness in the macular area and elsewhere, a thin, elongated slit-lamp beam with bright illumination is used. Patients who are sensitive to light can be examined using a red-free filter. When a red-free filter is used, choroidal naevi are more difficult to visualise but haemorrhages, intraretinal microvascular abnormality (IRMA) and neovascularisation are usually easily visible.

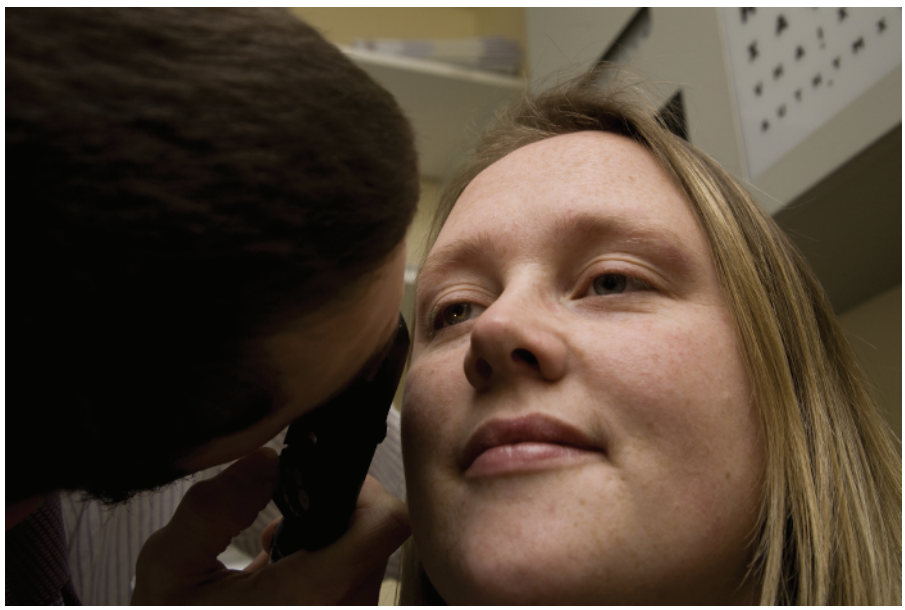


Fig. 1.4 Direct ophthalmoscopy.

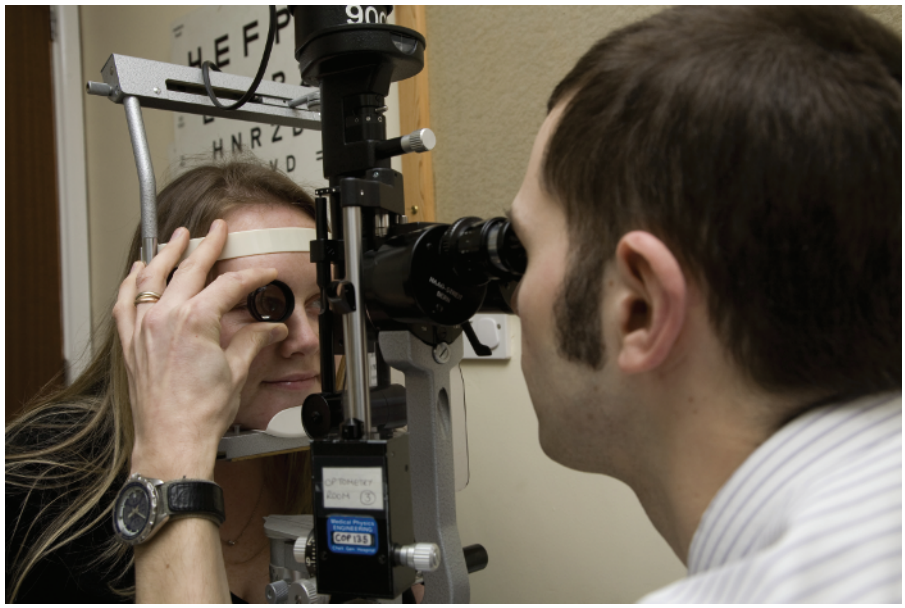


Fig. 1.5 Slit-lamp biomicroscopy with 78D lens.

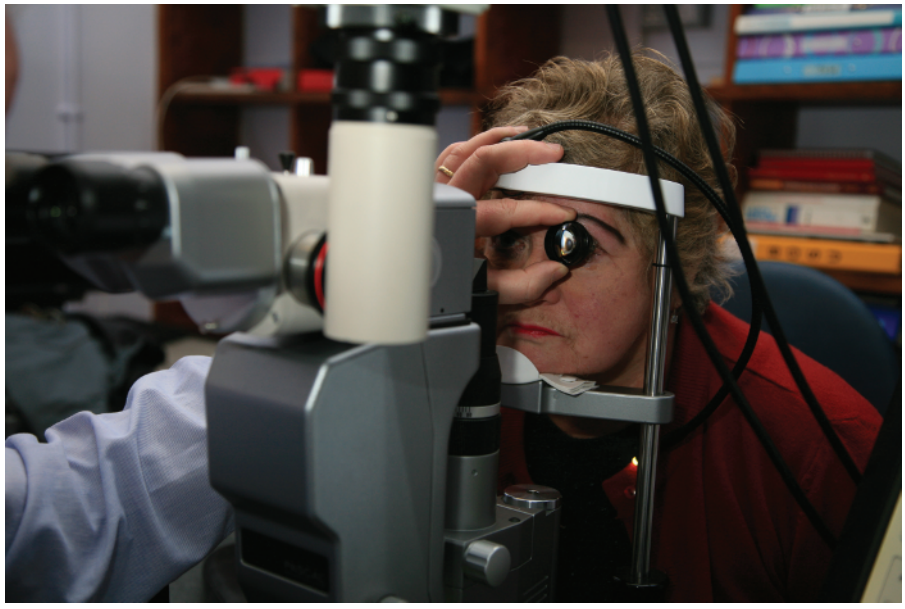


Fig. 1.6 Contact lens biomicroscopy.

Binocular indirect ophthalmoscopy

Binocular indirect ophthalmoscopy (BIO) is useful for evaluating the posterior segment and retinal periphery (see Figs 1.7 and 1.8). A larger area can be viewed than with slit-lamp biomicroscopy, but this view is less magnified.

The BIO is adjusted for the operator's interpupillary distance; the illumination system is usually placed in the upper one-third of the field for the superior retina examination and lower one-third for the inferior retina. Lens powers used for binocular indirect ophthalmoscopy vary from +14D to +40D lenses. The 20D lens is often

Fig. 1.7 Binocular indirect ophthalmoscopy.

Fig. 1.8 Binocular indirect ophthalmoscopy.

used as it provides adequate magnification and field of view in most situations. As the lens dioptre increases, the width of the field of view increases. The lower the power of the condensing lens, the further from the eye it must be held. The stronger the power of the condensing lens, the closer it must be held towards the eye. To achieve high magnification with any lens, the lens is kept stationary and the operator should move closer to it.

When performing binocular indirect ophthalmoscopy, the best position for the patient is reclined. The addition of scleral depression enables one to further evaluate the retinal periphery when required.

MULTIDISCIPLINARY MANAGEMENT

There are a number of risk factors for progression of diabetic retinopathy that do not usually come within the remit of the ophthalmologist's management of the patient, such as control of blood glucose, blood pressure (BP) and lipids. It is very important for the ophthalmologist to be aware of the control of these risk factors in the individual patient and to have good communication with the diabetic physician or general practitioner who is looking after this aspect of the patient's management.

A rapid improvement in diabetic retinopathy can sometimes be seen when a previously uncontrolled hypertensive receives adequate treatment for their BP. Similarly, a patient who has had poor renal function who commences renal dialysis nay show an improvement in their diabetic retinopathy independent of their BP control.

It is important for the ophthalmologist to be involved when a patient who has had poor glucose control and high HbA1c values for a number of years suddenly decides to dramatically improve their control with the assistance of their diabetic physician. Monitoring for a deterioration of their diabetic retinopathy in the first 6–12 months following the rapid improvement of diabetic control caused by the 'early worsening phenomenon' (described in Chapter 7) is required, particularly if any diabetic retinopathy is present at baseline.

INVESTIGATIVE TECHNIQUES TO ASSESS DIABETIC RETINOPATHY

Retinal photography, fundus fluorescein angiography, ocular coherence tomography and ultrasound B-scan examination are described in Chapter 5.

Perimetry

Perimetry is the systematic measurement of differential light sensitivity in the visual field by the detection of the presence of test targets on a defined background in order to map and quantify the visual field. There are two main methods for undertaking perimetry: (1) kinetic stimulus presentation; and (2) static stimulus presentation.

Goldmann kinetic perimetry

The most common visual field equipment used for kinetic assessment is the Goldman perimeter. It is a large hemispherical bowl of radius 30 cm with a standardized white interior brightness onto which stimuli of various sizes and brightness are projected. Patients are required to maintain fixation on a central target while a stimulus of specified size (from 1 mm to 5 mm diameter) and brightness is moved slowly from the patient's peripheral area of 'non-seeing' into the area of 'seeing'. When the patient first detects the light stimulus, they respond by pressing a buzzer to alert the operator (Fig. 1.9a and b).

The stimulus is moved systematically by the perimetrist to examine areas of the visual field. Points of equal retinal sensitivity are mapped onto a chart, which when joined together produce a contour line called an 'isopter'. Any contraction of the visual field, area of reduced sensitivity or blind spot becomes evident as they are mapped out (Fig. 1.10).

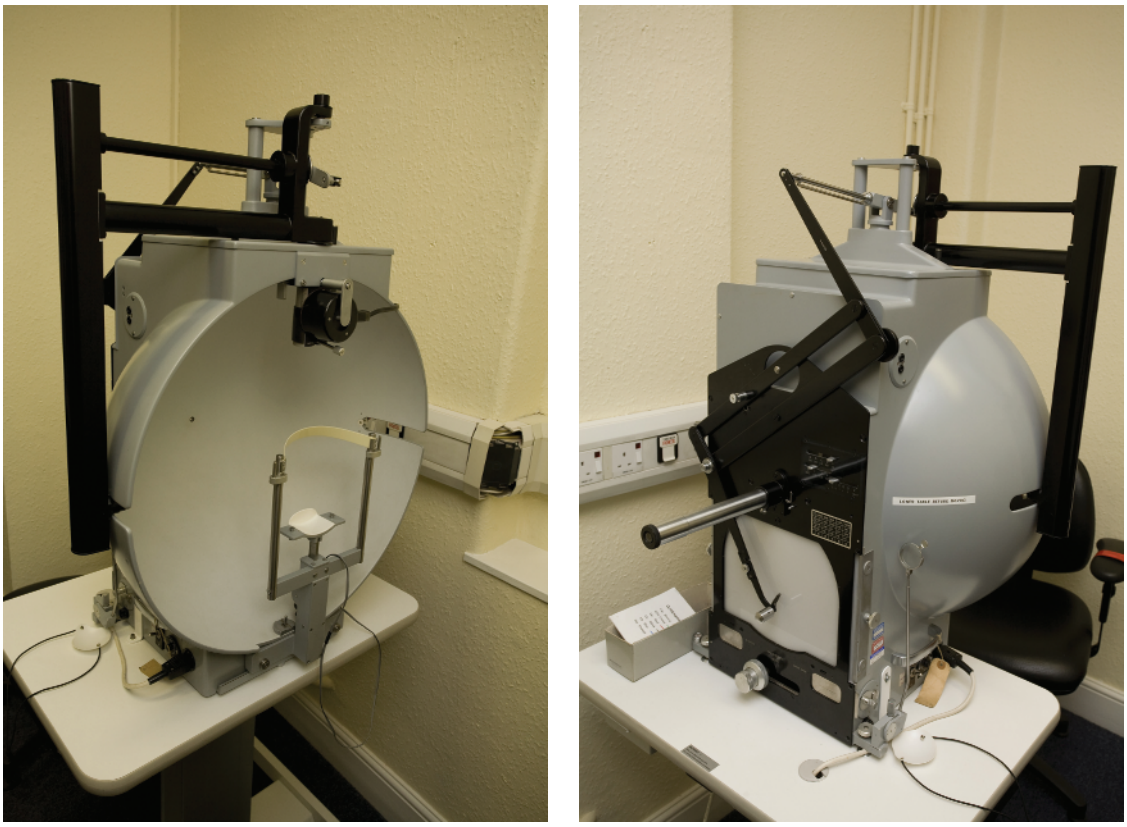
Goldmann perimetry is particularly helpful in the detection and diagnosis of neurological visual field defects, for example quadrantinopia and hemianopia. Due to the subjectivity and versatility of the examination procedure, the assessment requires an experienced and skilled perimetrist.

Automated static perimetry

Automated perimeters use static light stimuli, of various intensities at fixed locations within a hemispherical bowl, to provide an accurate measurement of retinal sensitivity. Automated perimeters are particularly effective in identifying and quantifying defects within the central visual field and are used routinely for screening for abnormality and for quantifying progression of defects. The equipment employs various testing strategies which are selected by the clinician based on the underlying pathology, suspected pathology and the level of detail required (screening or detailed quantification of defects).

The testing procedure involves presenting single- or multiple-patterned, static light stimuli in a pre-selected, random order to minimize patient prediction. Once the stimulus is observed, the patient responds either verbally or via means of a buzzer. The pattern of stimuli presented and the time taken to complete the test is dependent on the strategy selected. Visual field examination can be time-consuming for the patient who may be required to concentrate for long periods of time. Optimizing the length of testing time to reduce patient fatigue and to maximize performance is an important factor in test selection and in obtaining reliable results.

The Humphrey visual field analyser is generally considered to be the most common visual field equipment in use in UK ophthalmology departments (see Fig. 1.11). Normal visual field examination requires each eye to be tested



(a) (b)

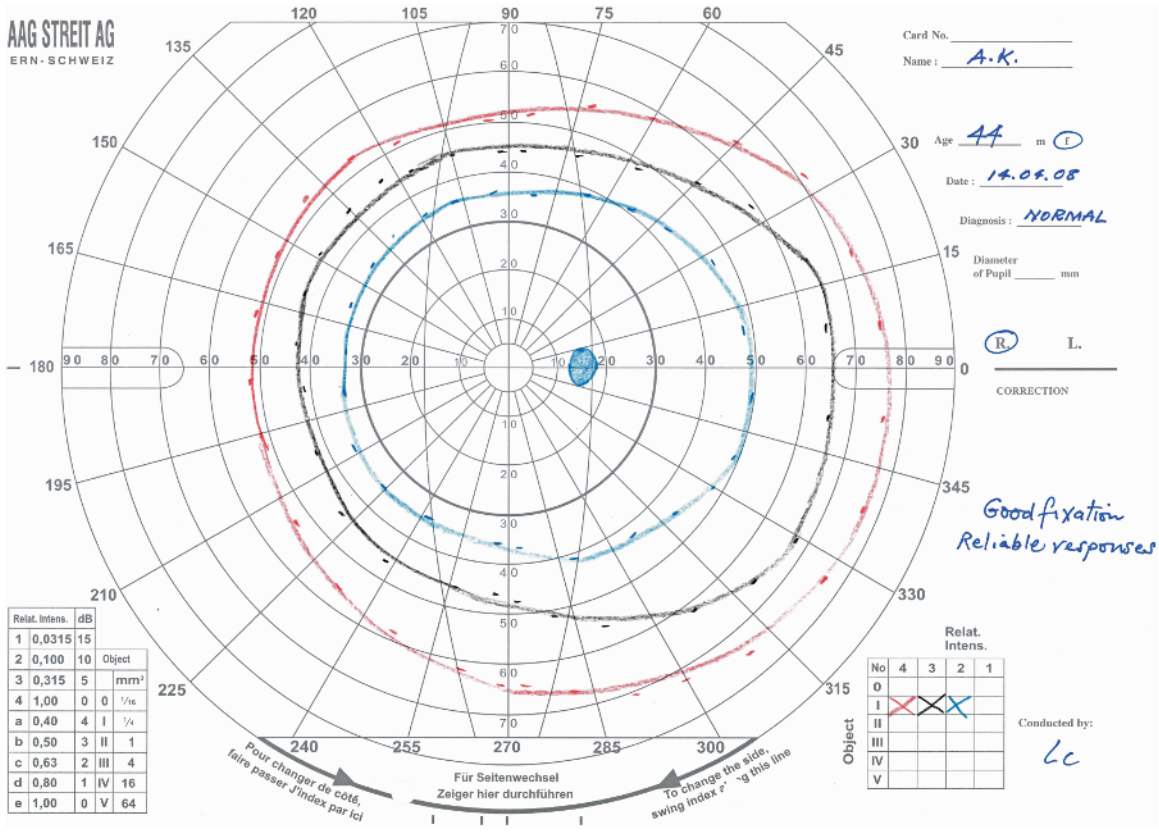
Fig. 1.9 Goldmann Perimeter: (a) patient view and (b) operator view.

independently (Fig. 1.12a and b). One eye is covered while the other maintains accurate, central fixation for the duration of the test. Occasionally, binocular visual field testing is required for patients who have undergone panretinal photocoagulation, resulting in peripheral visual field constriction or defects within the central 20 degrees. This may impact on a person's ability to meet the UK Driver and Vehicle Licensing Agency (DVLA) visual field standard. This requires a binocular assessment to be undertaken, using the Esterman grid testing pattern. A series of 120 points, at a specified light intensity, are presented individually across a rectangular area extending over 150 degrees of the horizontal binocular visual field. Holders of a UK driver's licence are required to meet the standard of a horizontal visual field of at least 120 degrees, with no significant central defect (see Fig. 1.13a and b). (For detailed information on the visual standards required for driving, please refer to the DVLA, www.dvla.gov.uk).

THE APPLICATION OF LASERS IN DIABETIC RETINOPATHY

The acronym laser is defined as light amplification by simulated emission of radiation. Coherence is one of the unique properties of laser light. It arises from the stimulated emission process which provides the amplification, and the emitted photons are 'in step' and have a definite phase relation to each other. Spatial coherence tells us how uniform the phase of the wave front is, which gives us the ability to precisely focus the laser beam to apply very small burns to pathological tissue with minimal disturbance to surrounding tissue. Temporal coherence tells us how monochromatic a source is, and this gives us the ability to select a very narrow bandwidth of light that is preferentially absorbed by the pathological tissue site.

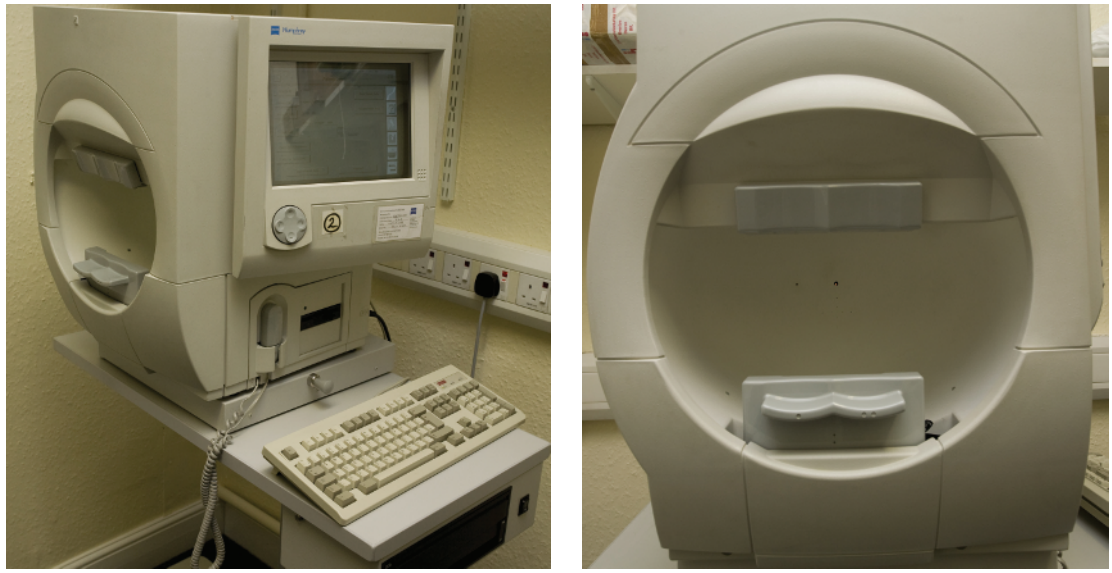
With the improvement of laser technology, different types of laser are used in the diagnosis and treatment of



Relat. Intens.		dB
1	0,0315	15
2	0,100	10
3	0,315	5
4	1,00	0
a	0,40	4
b	0,50	3
c	0,63	2
d	0,80	1
e	1,00	0

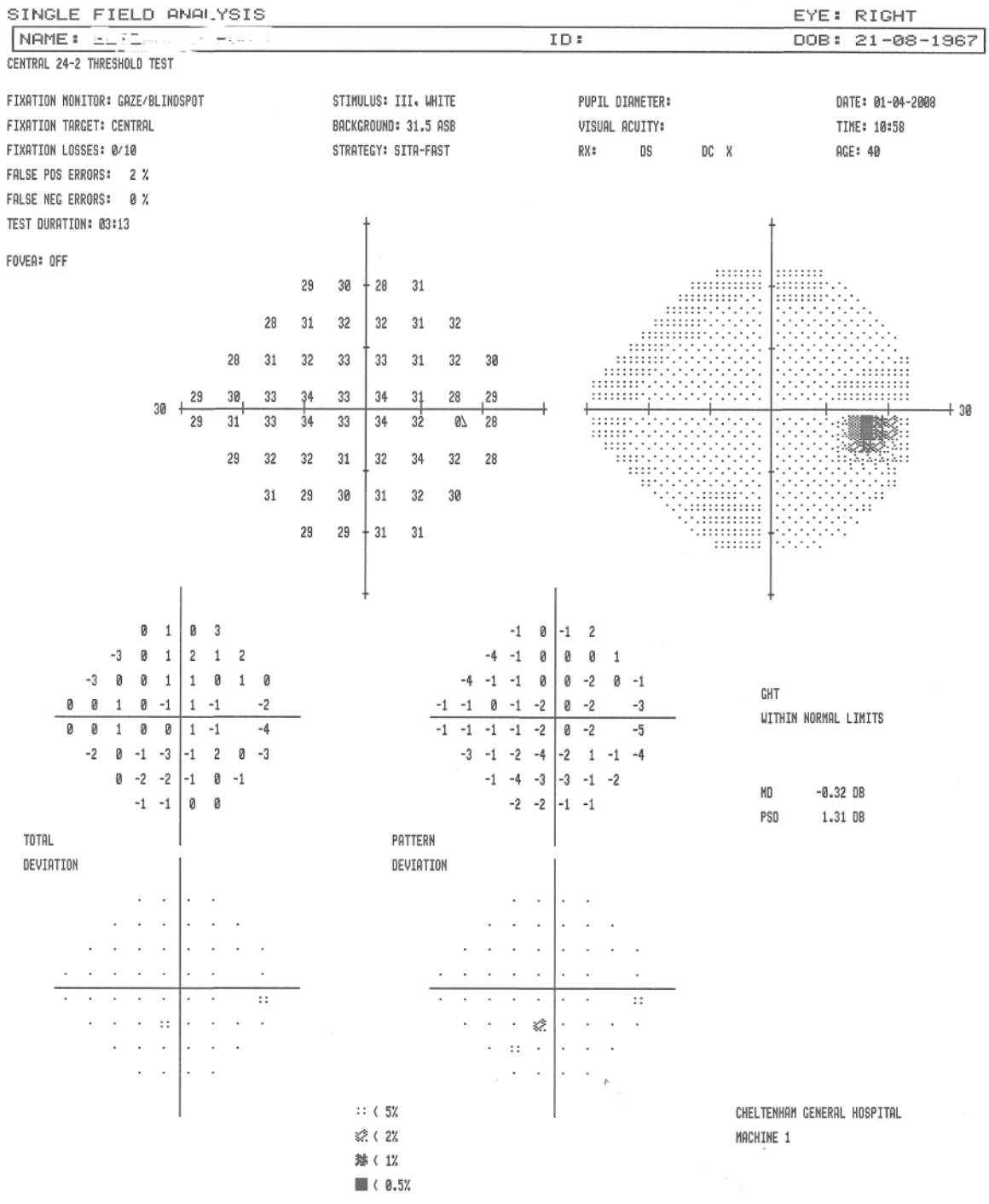
Object	
	mm²
0	1/16
I	1/4
II	1
III	4
IV	16
V	64

Fig. 1.10 Example of a normal Goldmann visual field.



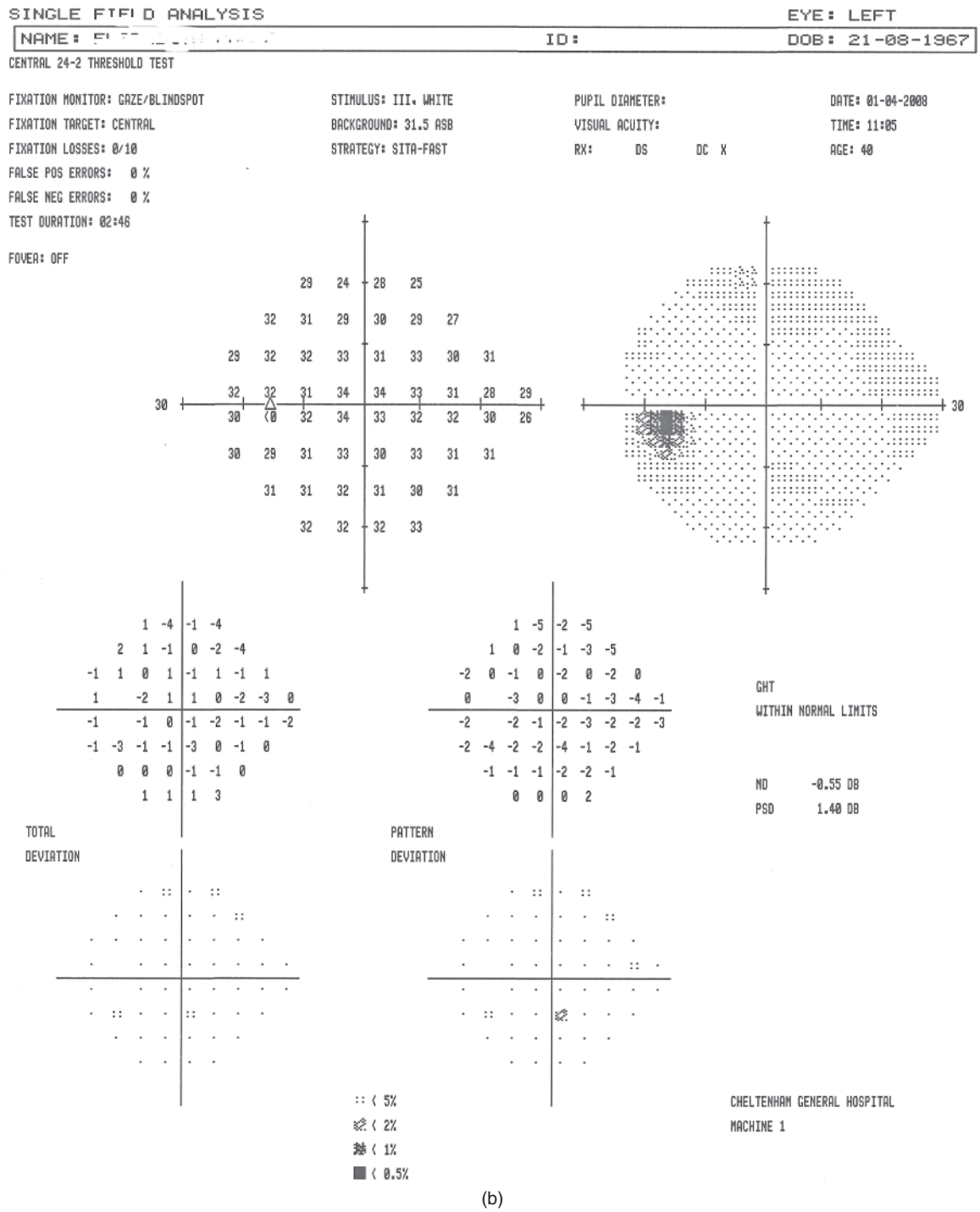
(a) (b)

Fig. 1.11 Humphrey visual field analyser: (a) operator's view and (b) subject's view of where the chin and forehead are rested and the view of where individual lights are presented to test the field of vision.



(a)

Fig. 1.12 (a, b) Example of a normal Humphrey visual field for right and left eyes.



(b)

Fig. 1.12 *Continued*

many eye disorders. Laser–tissue interactions can occur in several ways but are broadly grouped under photothermal, photochemical and photoionising effects.

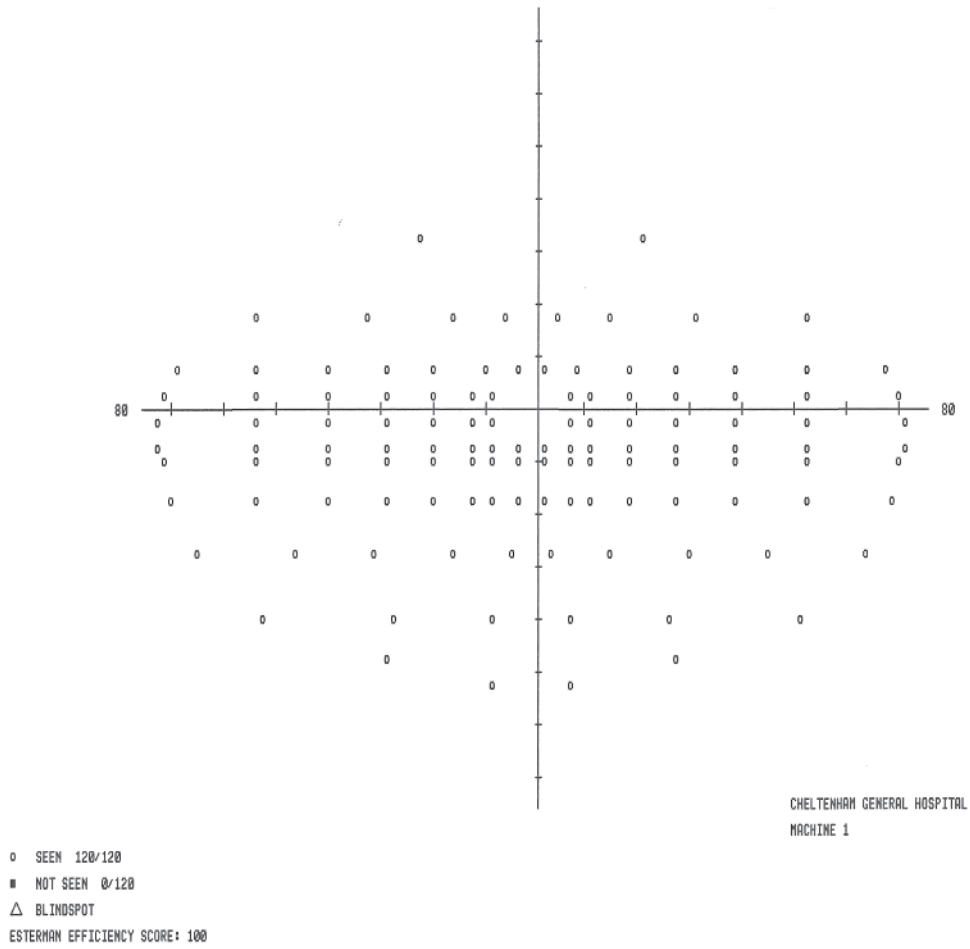
When lasers are used for the treatment of diabetic retinopathy, they rely principally on the effect of photocoagulation. Two other clinical effects of lasers commonly used in ophthalmology are photodisruption and photoablation, all defined in the following.

Photocoagulation

Photocoagulation (photothermal effect) causes denaturation of proteins when temperatures rise sufficiently. The temperature rise in tissues is proportional to the amount of light absorbed by that tissue. The retinal pigment epithelium absorbs light due to the melanin content and blood vessels absorb light due to their haemoglobin content. Lasers commonly used for photocoagulation are argon, krypton or diode Nd:YAG lasers.

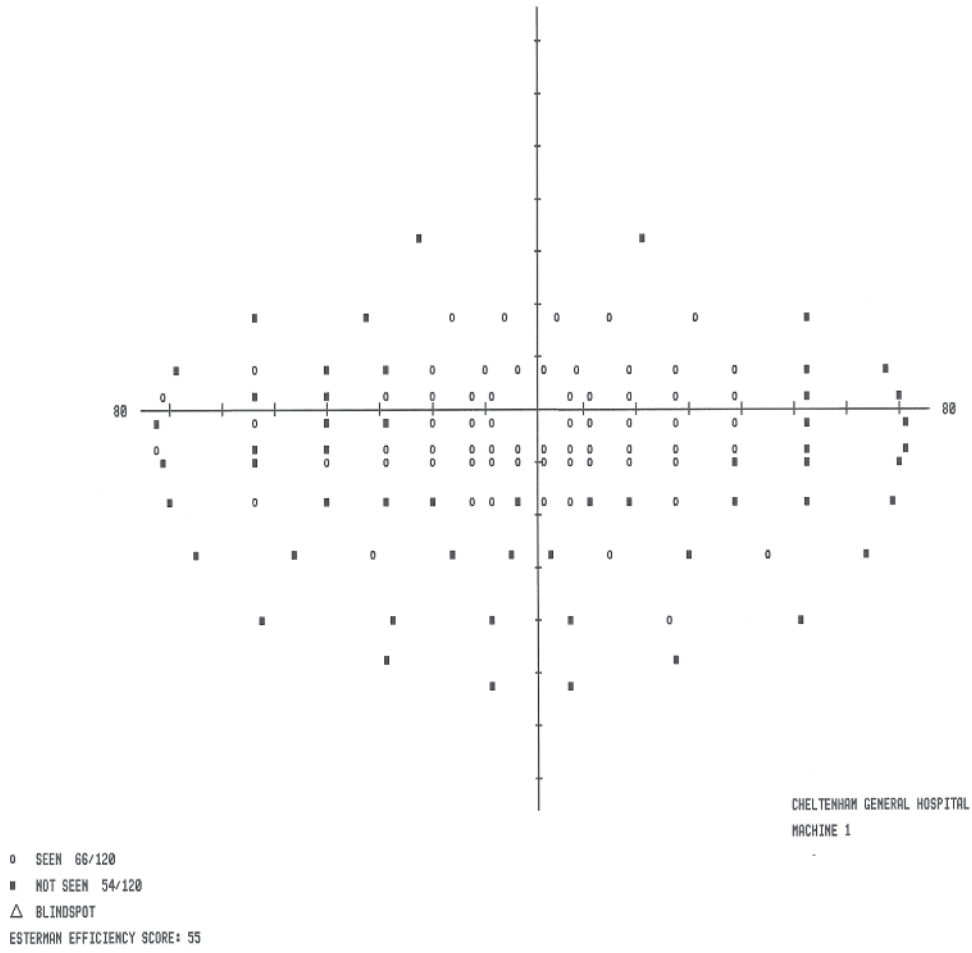
Photodisruption

Photodisruption (photoionising effect) is the process by which short-pulsed, high-power lasers disrupt tissues by delivering irradiance to tissue targets such as the peripheral iris, producing a laser iridotomy for the prevention of angle-closure glaucoma using an Nd:YAG Q-switched laser.



(a)

Fig. 1.13 (a) Example of a normal Esterman visual field. (b) Example of a restricted Esterman field in a diabetic patient. The case history of this patient is described in Chapter 9 on proliferative and advanced diabetic retinopathy.



(b)

Fig. 1.13 *Continued*

Photoablation (photochemical effect)

Photoablation (photochemical effect) describes the process by which tissue is removed in some way by light, such as when intermolecular bands of biological tissues are broken, disintegrating target tissues, and the disintegrated molecules are volatilised. The excimer laser uses photoablation in photorefractive procedures, for example photorefractive keratectomy (PRK) and laser subepithelial keratectomy (LASEK).

Active laser media

Active laser media are available in the following states:

- solid (crystalline or amorphous; e.g. Nd:YAG laser, Rubin laser);
- liquid (e.g. dye laser);
- gaseous (e.g. argon ion laser, CO_2 laser, excimer laser); or
- other (e.g. diode laser).

A laser gain medium is the active medium of the laser which can amplify the power of light. The term gain refers to the amount of amplification. Energy is pumped into the active medium in a very disorganized form and is partially transformed into radiation energy, which is highly ordered.

Light wavelengths produced by different lasers

Argon blue-green lasers produce light over a narrow bandwidth, the main peaks being at 488 and 514 nm.

This laser is the most common laser that is used in diabetic retinopathy treatment for both panretinal laser and macular laser treatment.

The Pascal pattern scan laser is a frequency-doubled Nd:YAG diode-pumped solid-state laser producing light of wavelength 532 nm. This laser was introduced in June 2006 and it is unique in that it allows the operator to apply multiple spots almost simultaneously in pre-chosen patterns of up to 25 spots.

Diode lasers were introduced in 1993 with reports of laser-emitting diodes of gallium-aluminium-arsenide which were portable, and their wavelength of emission was 810 nm. Most of the laser energy from the diode laser is absorbed by the pigment in the melanocytes in the choroid, which made it more difficult for the operator to define the correct treatment power to use and was more painful for patients.

PRACTICE POINTS

Modern technology has produced major advances in the investigations and treatment that can be undertaken in our diabetic patients over the last 30 years. However, a carefully taken history and high-quality clinical examination is a vital component of the care of any patient with diabetic retinopathy.