

# **Diabetic Retinopathy Screening**

## ***Digital Imaging***

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Unit 006 – Imaging the eye**

## Imaging in Retinopathy Screening

This paper, and the accompanying presentation, aims to provide basic information about various aspects of digital fundus imaging when screening for diabetic retinopathy. There are a number of sections:

### 1. Camera settings

*The correct settings for some of the digital camera backs*

### 2. Artefacts and examining the image

*Differentiating pathology from photographic artefacts*

### 3. Field positions, clarity and overall quality

*The 2 standard fields to be imaged for screening purposes*

### 4. Protecting the computer system

*Firewalls, anti-virus, anti-spyware*

### 5. Backup

*This section is more to do with protecting your own images, since the screening scheme will have its own backup arrangements.*

### 6. Assignment Tasks and assessments

*Achieving the competency level*

## 1. Settings

The possible cameras in circulation include:

### ***With separate digital backs:***

Canon CR6 and DGi with digital backs: D30, D60, 10D, 20D, 30D

Topcon NW6 with digital backs: Nikon D1H, D1x, D70 and D70s (and the odd Fuji)

Kowa NonMyd7 with digital back: Nikon D100

Nidek AFC210 with Canon EOS 5D

### ***With integrated digital backs:***

Topcon NW100/200

Zeiss Visucam

Kowa NonMydalpha

Nidek NM1000

Not all of the settings mentioned may be available for the integrated backs so for these you should refer to the manufacturer's instructions. Nevertheless, for some settings such as resolution and compression the same principles apply to all cameras, with the exception of the 8mega pixel Canon 20D and 30D and 12mp Canon 5D.

### **Resolution**

This is the number of pixels in the final image and in most cases the resolution should be set to the highest figure. An exception might be the Canon 5D on the Nidek AFC210 for which one might choose to reduce the resolution to 6 mega pixels with best quality compression or (as in the next paragraph for the 20D & 30D) use the highest (12mp) resolution but the "normal" compression.

### **Compression**

This is the extent to which information is discarded in order to reduce the file size. In all cases except the 8mega pixel Canon 20D and 30D the JPEG compression should be set to the best quality (least lossy). For these 2 Canons this would result in too large a file size for easy transmission in retinopathy screening schemes, so the author's recommendation is to use the highest resolution and the "normal" JPEG setting (giving files of approx 800KB (one down from fine which gives nearly 2MB).

### Shutter speed

For Canon this is 1/60<sup>th</sup> second and for Nikon backs Topcon recommend 1/30<sup>th</sup> second. In both cases the cameras should be set to “M” for manual.

### ISO Setting

This is the sensitivity and is based on the speed rating used with film in which the higher the number, the more sensitive the film but the grainier the result. The effects are similar with digital cameras with a higher sensitivity setting allowing the capture of images in lower illumination but with more noise (which is similar to grain) as a result.

For both Canon and Nikon this should be set to ISO200

### Colour Balance

This affects the colour cast of the image and can be set to correct for images taken in tungsten light as opposed to daylight. For this purpose the safest setting is “auto white balance”. Some suppliers are recommending “tungsten” setting for white balance but this can makes images more difficult to compare between different cameras and is not advisable for screening purposes. Auto white balance will also correct for any changes in the colour of the flash tube as it ages.

### Canon 20D



**D30/D60/10D:**  
Large/Fine  
**20D/30D:**  
Large/Normal  
**M** for manual  
**1/60th**  
**ISO 200**  
**Auto Colour Bal**

**Manual**



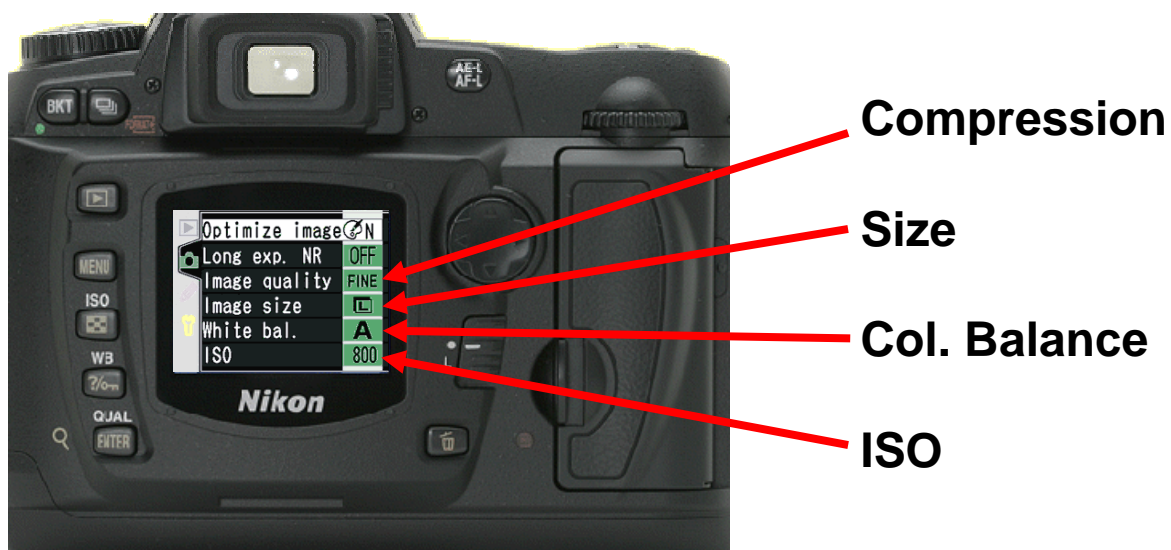
**ISO**

**Speed**



**Colour balance**

### Nikon D70



Large/fine  
M for manual  
1/30th  
ISO 200  
Auto Colour Balance

**Manual**



**Speed**



## 2. Artefacts and examining the image

Artefacts are anomalies in the optical imaging pathway that appear on images for a variety of reasons. In some instances they can mimic pathology. Normally it is fairly easy to differentiate them from possible pathology because they appear in the same place on all images!

**Dust on the sensor** tends to take the form of dark specs and will disappear or move if the sensor is cleaned. Hold a piece of white card in front of the objective (a few inches away or reduce the flash intensity if you hold it close) and the resultant photo will clearly show any sensor dust. There will also generally be a “hot spot” centrally. The camera is designed to spread the light evenly over the curved retina of the typical eye after passing through the cornea and crystalline lens. Clearly a flat white piece of card falls outside the norm and results in an uneven spread of light.

The sensor is best cleaned with a blast from a can of compressed air which can be bought in photographic shops. Remove the camera from the mount and follow the camera instructions in order to move the mirror out of the way. Hold the camera upside down and direct a jet of air at the sensor. Manufacturers generally advise that the sensor should not be touched.

**Soft central hot spots** that start to appear quite frequently on images indicate a build up of film on the internal condensing lens. To clean this requires a visit from the service engineer and is one of the reasons you pay for your maintenance contract!

**Darker hot spots** often appear on photos of very myopic patients and are due to the ocular dimensions being outside the normal range.

**Very soft spots** can sometimes be seen on low contrast pictures. These seem to be a sensor anomaly and generally cannot be removed from the sensor by cleaning.

**Muck or fingerprints** on the objective lens can cause quite dramatic effects – often large silvery areas. Smaller patches, however, can look similar to floaters – the difference being that they appear on pictures of both eyes and don't move in sequential pictures of the same eye.

**A shower of bright spots** on pictures taken slightly out of line is dust on the objective lens.

**A bright crescent** usually appears at one side when the eye is not quite lined up – often the patient has lost fixation at the last moment. This often happens with the Canon DGi with poorly dilated pupils due to the absence of an edge mask.

**A pale ring** or loss of contrast and increase in brightness at the edge is due to incorrect positioning – too close or too far away.

### **Identifying artefacts**

Always check to see if an unusual is repeated in the 2<sup>nd</sup> field of the same eye and/or in the images of the other eye. Any effect which appears in the same place within the field on all images must be an artefact not pathology. An effect which appears in the same place on the retina in both fields of the same eye must be retinal. A cloudy patch which moves slightly and is present in one eye only is likely to be a vitreous floater (see below).

## Other anomalies

**Reflections from the posterior vitreous face** can sometimes give the impression of being hard exudates. If the same area of retina is visible in the second image, a reflection will often look different or be absent. If in doubt, take further photographs with a slightly different angle of view in addition to the two required views. Such views can be labelled L/R Other, as opposed to Nasal or Temporal.

**Floaters** appear as slightly cloudy patches which obscure the retinal detail beneath them. Ask the patient to flick their eyes side to side or up and down then take a second shot. The floater will usually appear in a slightly different place.

## Examining the image

### Monitors

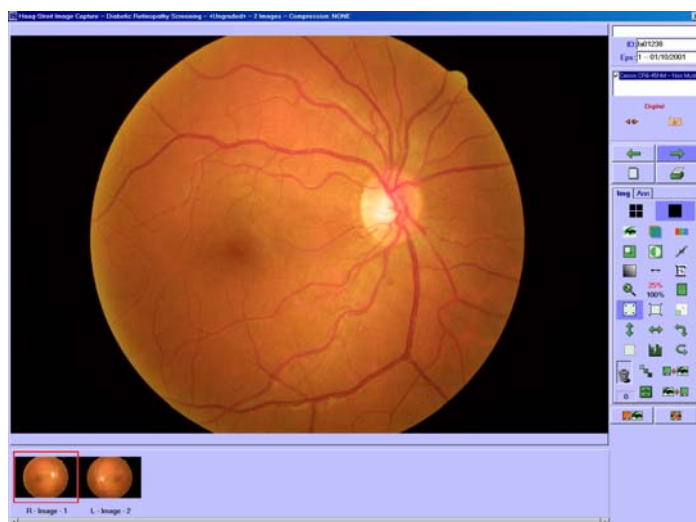
The increasing availability of high quality flat panel displays (FPDs) at lower prices means that there has been a huge shift in sales of monitors away from CRTs. It is probable that commercial pressures will mean CRT monitors begin to disappear from production.

**CRTs**, which use a scanning electron beam to excite phosphors, can display various differing resolutions on the same monitor, depending on the setting. FPDs have a fixed number of pixels (their “native” resolution) and running them at anything other than this native resolution will result in a poor quality display.

**FPDs** are available in resolutions of up to 1600x1200 at fairly reasonable prices and good ones give excellent quality viewing. Resolutions higher than this are available but increase the cost considerably. The current camera specification says images should be viewed at 100% size, although high-resolution images may be re-sized for viewing so long as the effective resolution equals or exceeds the minimum imaging resolution of 20 pixels per degree. It also says that at least 65% of the image should be visible at once. It is worth exploring further what this means in practice.

With the specified field of view of 45° x 40° the minimum resolution equates to 900 pixels by 800 pixels. So on a screen of resolution 1600x1200, so long as no more than 33% of the screen vertically and 43% horizontally is taken up by software menus, buttons and toolbars, then even if the image is sized such that the whole field of view is visible, it will still effectively equal or exceed the minimum resolution when displayed. This is likely to be the case with most grading software. If the image is enlarged so that 65% is visible vertically (which is the limiting direction), then the effective resolution is just over 30 pixels per degree.

*This picture shows imaging software running on a screen resolution of 1600x1200. The area occupied by the fundus image measures 1380x970 pixels, so the effective resolution exceeds 20 pixels per degree.*



The conclusion to be drawn from this is that viewing an image on a screen with a resolution of 1600x1200 means that the viewing criteria can always be met, regardless of the original image size. FPDs must always be operated at their native resolution. At the time of writing all FPDs with a resolution of 1600x1200 are 20" screens or larger.

### Viewing

What this all means is that images should normally be enlarged to 100% size for viewing purpose. With high resolution cameras this may result in an excessive amount of scrolling in order to view the whole image. In this case it is permissible to reduce the image size slightly.

*Images should normally be enlarged for viewing purposes.*



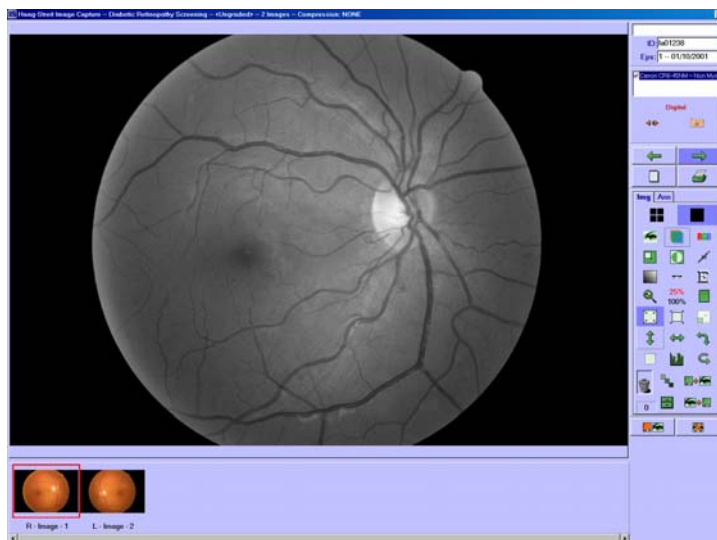
### Red Free / Green Plane

It useful to enhance the contrast of images as this often makes blood vessel pathology such as new vessels and micro aneurysms much more easily visible. The terms red free and green plane are often used interchangeably but, strictly speaking, red free is the nature of light used to enhance contrast when viewing, whilst green plane refers to viewing only the information contained in the green channel of a colour image.

An example of red free light is that produced by the turquoise filter on a slit lamp which is used to enhance contrast of anything coloured red. A similar effect can be recreated in software on a colour image by only displaying the information contained in the green colour channel, and rendering this on screen as a monochromatic image. This is known as the green plane. It should be noted that this is not the same effect as “green filter”. As a rule, green plane images are better for detecting vascular abnormalities than “green filter” images.

All images being inspected for retinopathy should be viewed with the green plane filter as well as in colour. It is often surprising the pathology that would be missed without the enhanced contrast of the green plane.

*Images should always be viewed in green plane mode as well as in colour*

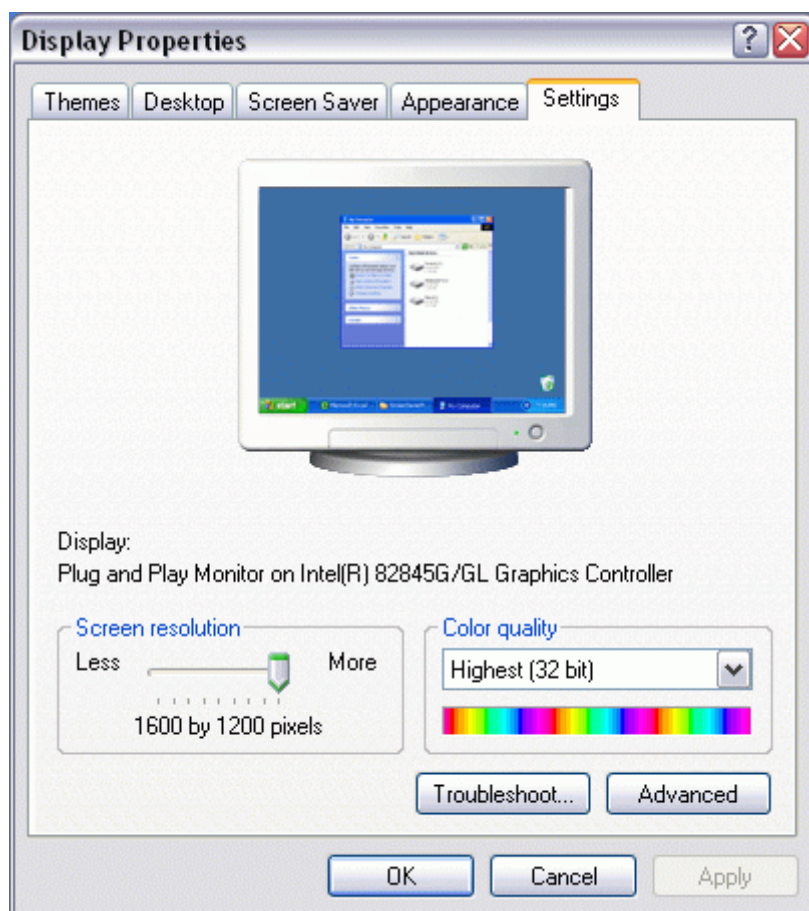


## Resolution settings

You should ensure that you know what the native resolution of your monitor is by checking the manual. Then check that the display resolution is correctly set to this figure in Windows. If operating the recommended monitor this should be 1600x1200.

To check that Windows is operating the monitor at the correct resolution:

- Right click on the desktop
- Choose “Properties”
- Then choose “Settings”
- Check the resolution figure is correct
- Check the colour depth is set to 32 bit  
*(all current computer/graphic card combinations should be capable of 32bit colour)*
- If the monitor is capable of displaying 1600x1200 but this value does not appear in the Screen Resolution box then your graphics card and/or its driver may need updating.





### 3. Field positions, clarity and overall quality

For retinopathy screening purposes in England two images are taken of each eye. These have overlapping fields of view and between them cover the main area of concern in respect of sight threatening diabetic eye disease. In accordance with the camera specification, the field of view will normally be a minimum of 45° horizontally and 40° vertically per image.

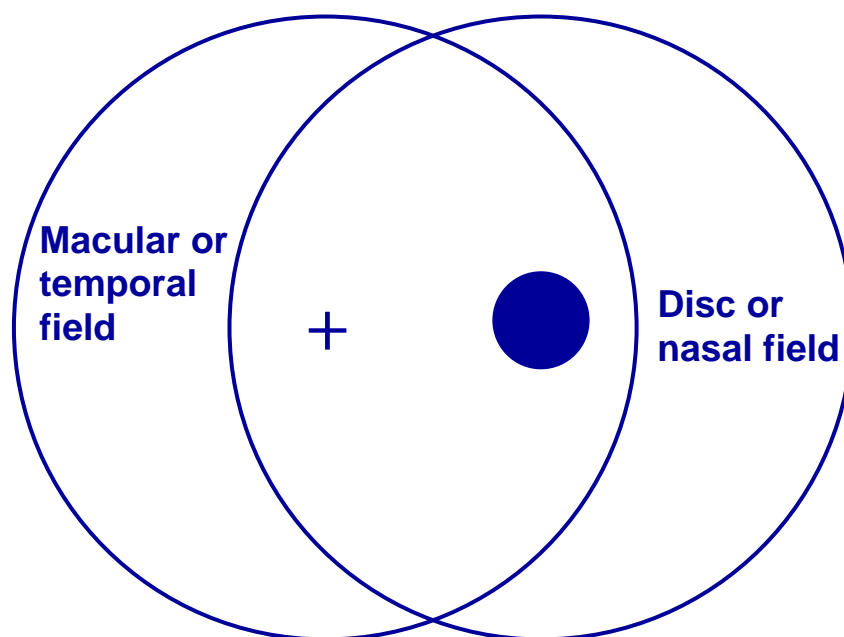
Taking two images has a number of advantages:

- It places the 2 important areas at the centre of each image.
- It covers a larger area of retina than one image alone.
- It helps to differentiate artefacts from pathology.

The two fields to be captured have a larger area of overlap than might be felt necessary but were chosen to simplify the capture by allowing the use of the internal targets of the fundus camera. They also allow a simple assessment of image positioning.

The two fields are:

- Macula centred, giving coverage of the temporal retinal.
- Disc centred. Giving coverage of the nasal retina.



#### **Positioning**

All images are assessed for position and are regarded as good, adequate or inadequate as follows:

##### **Macula field**

**Good:** Centre of fovea  $\leq 1$ DD from centre of image

**Adequate:** Centre of fovea  $> 2$ DD from edge of image

**Inadequate:** Failure to meet definition of **adequate** above

### **Disc field**

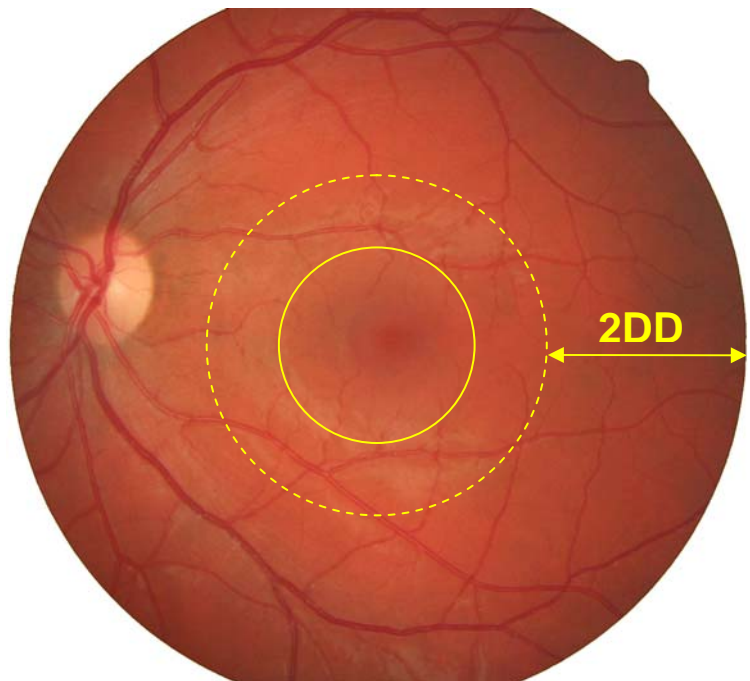
**Good:** centre of disc  $\leq 1DD$  from centre of image

**Adequate:** all of optic disc  $>2DD$  from edge of image

**Inadequate:** Failure to meet definition of **adequate** above

**Note:** Some large discs may meet the 'good' standard yet also be closer than 2DD to the edge, which is normally 'unacceptable'. In these cases, 'good' takes precedence.

To qualify as a **good** position the target (fovea or centre of disc) must fall within the centre circle which represents a circle of radius one disc diameter. For **adequate**, the fovea or any of the disc must not fall outside the dotted circle which is 2 disc diameters from the edge.



### **Clarity**

National targets are for the number of ungradeable images to be less than 10%, and ideally less than 5%. As part of the image quality assessment, images must also be assessed for clarity, by reference to the visibility of small blood vessels, as follows:

#### **Macula field**

**Good:** vessels clearly visible within 1DD of centre of fovea **and** visible across  $>90\%$  of image

**Adequate:** vessels visible within 1DD of centre of fovea

**Inadequate:** Failure to meet definition of **adequate** above

#### **Disc field**

**Good:** fine vessels clearly visible on surface of disc **and** visible across  $>90\%$  of image

**Adequate:** fine vessels clearly visible on surface of disc

**Inadequate:** Failure to meet definition of **adequate** above

Any lack of clarity in the optical components of the eye may lead to poor quality images. The most common reason will be cataract, but other causes include corneal scarring, corneal dystrophies, any corneal distortion such as kerataconus and small pupils that do not successfully dilate. Lack of ability to fixate can make positioning of the field challenging.

In the case of small pupils, it may be possible to take extra images using the small pupil setting of the fundus camera such that, when all images are considered together there is satisfactory coverage of the area of concern. Where this is the case, common sense dictates that (assuming quality is OK) an assessment of adequate is made, even though each image in isolation may appear inadequate. Screening software does allow more than 2 images per eye to be taken and labelled “R/L Other”

### **Final assessment of overall quality**

Each eye is assessed separately. For each eye, a combined assessment is made of both field position and image quality of the two images. In other words, for the right eye to warrant an assessment of good, the two images of the right eye must rate good for both position and clarity. If both images rate good for position, but one is only adequate for clarity, then the overall rating is adequate. If either position or clarity is inadequate for either image, then the overall assessment is inadequate with one exception – if referable retinopathy is visible anywhere then the images are regarded as adequate.

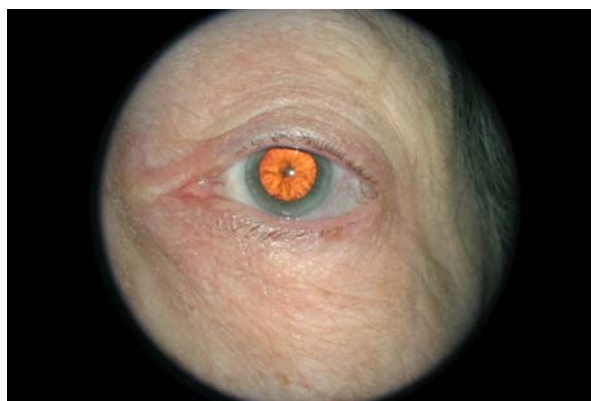
Images should only be utilised if the grader is confident the quality is sufficient and all grading must be performed by trained and accredited personnel.

### **External Photographs**

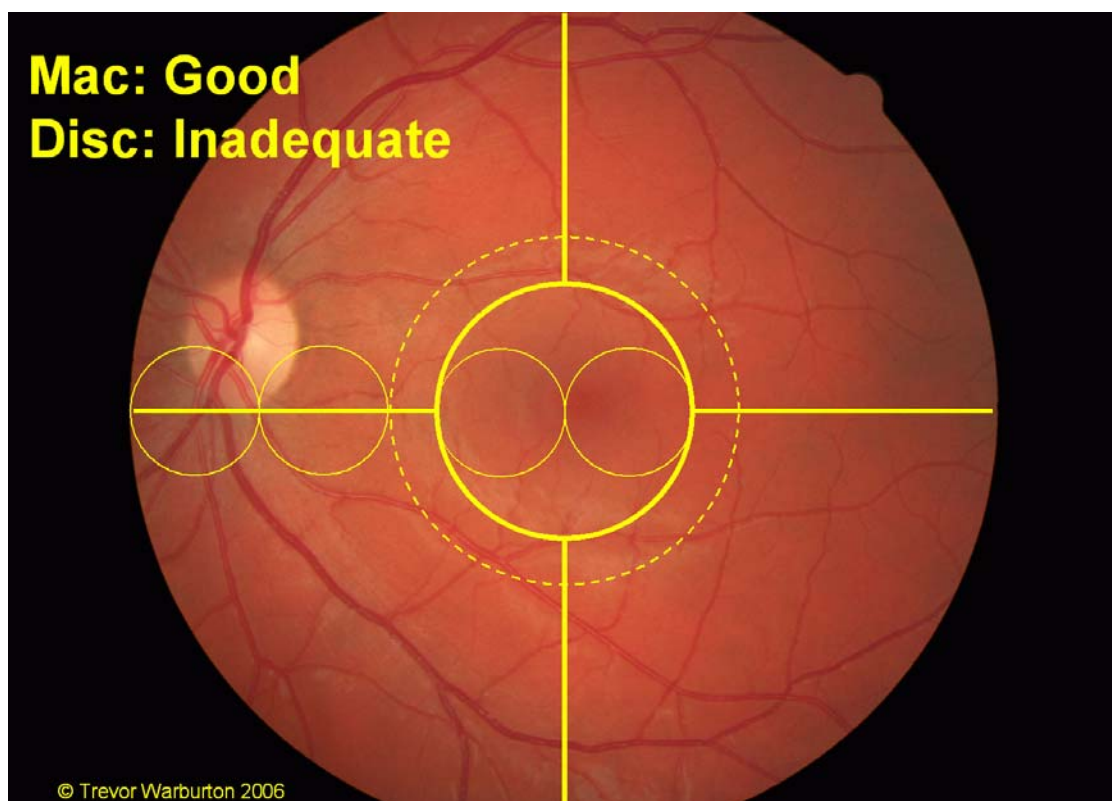
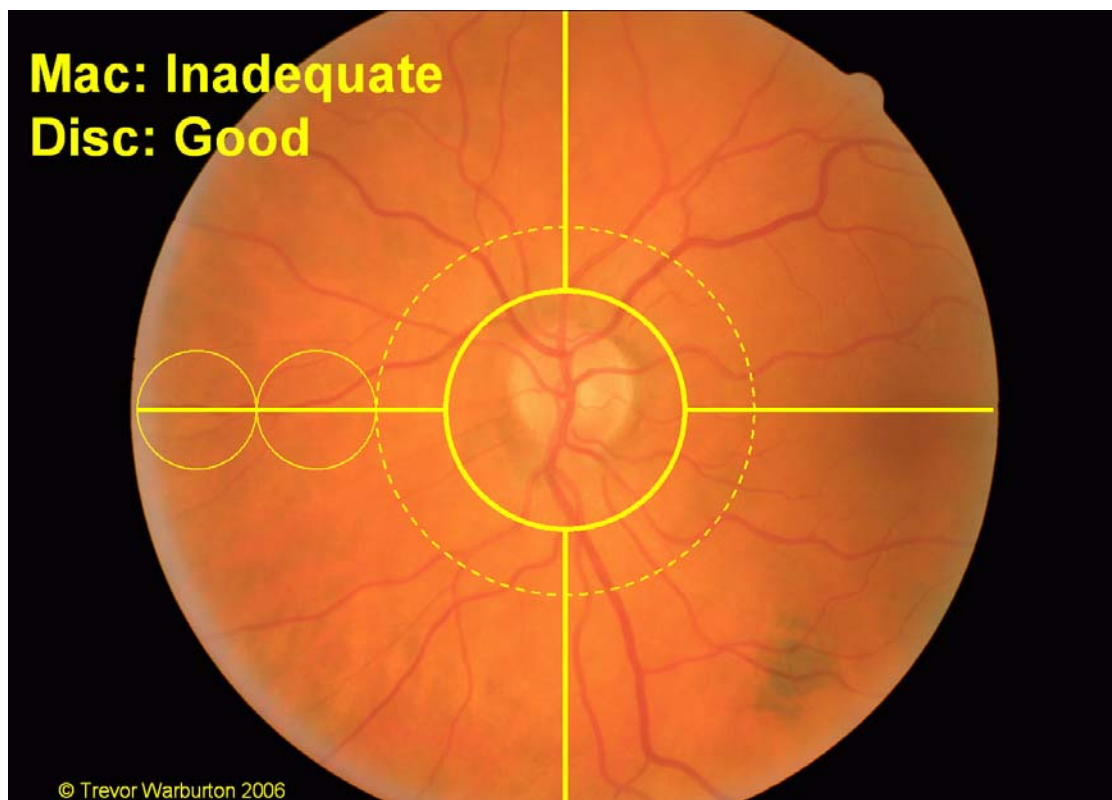
It is normal practice to take an external eye photograph showing the red reflex when photographs are judged ungradeable. This will generally give a clue to anyone else viewing the images as to the cause of the problem.

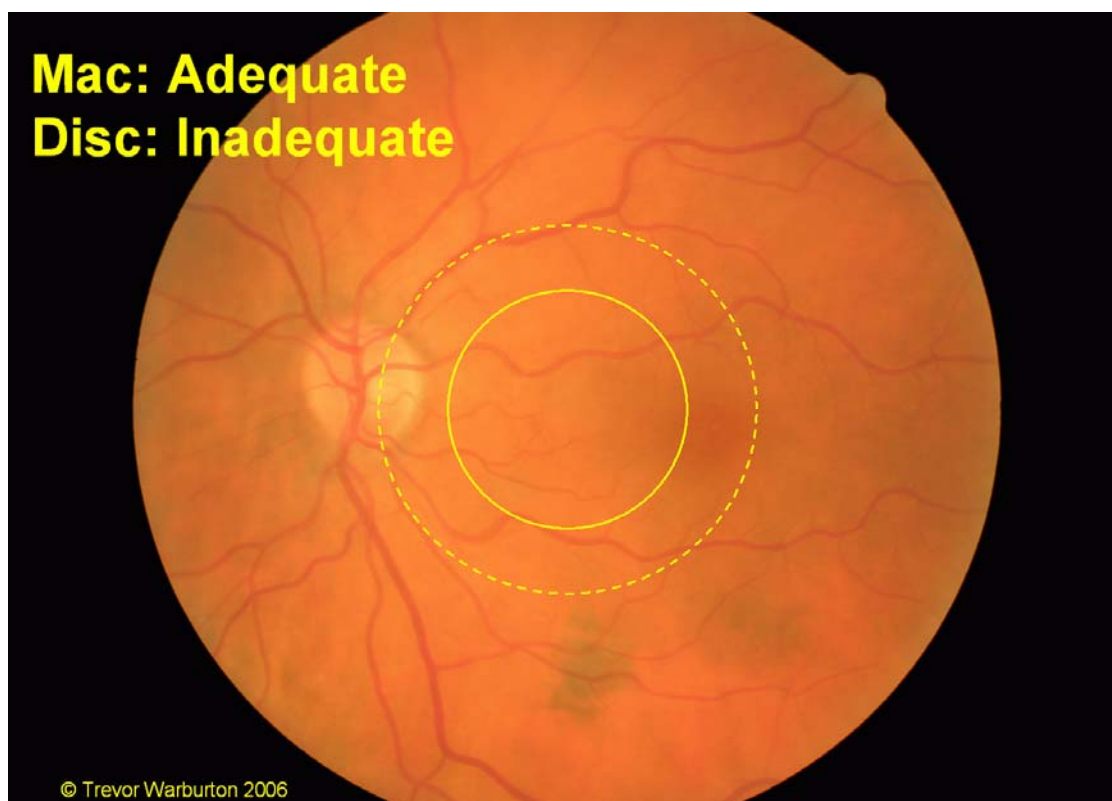
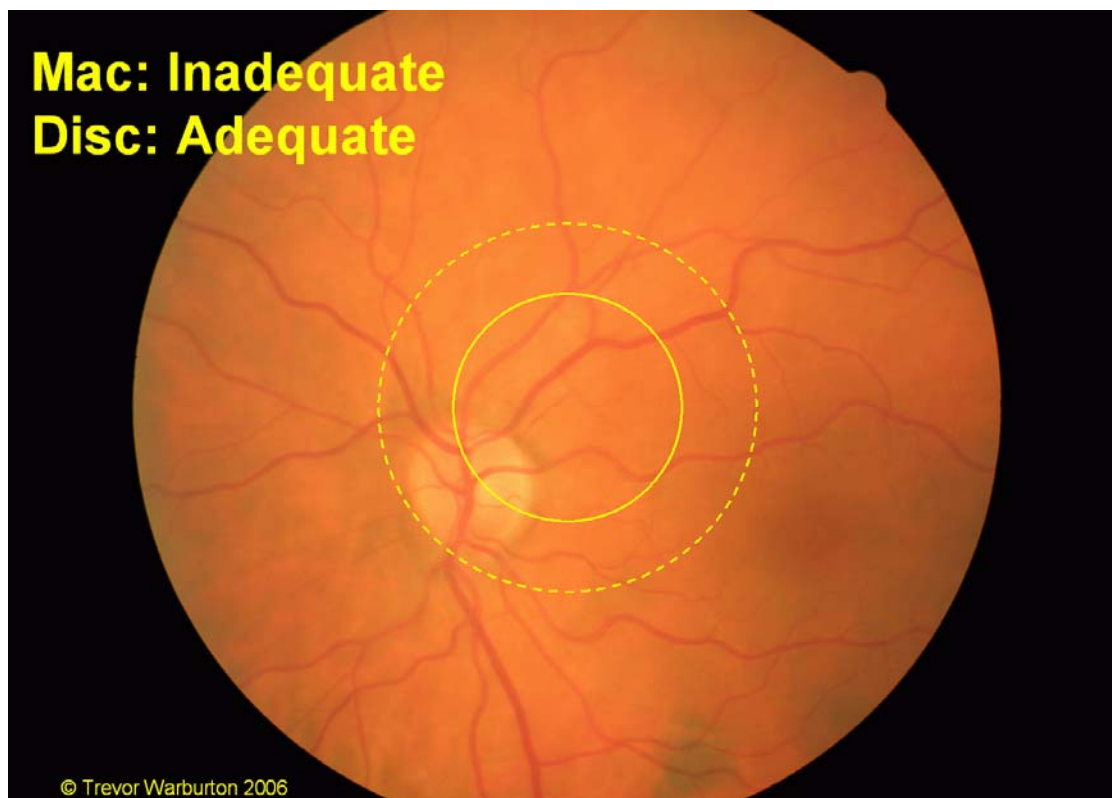
You can take external shots in one of 2 ways:

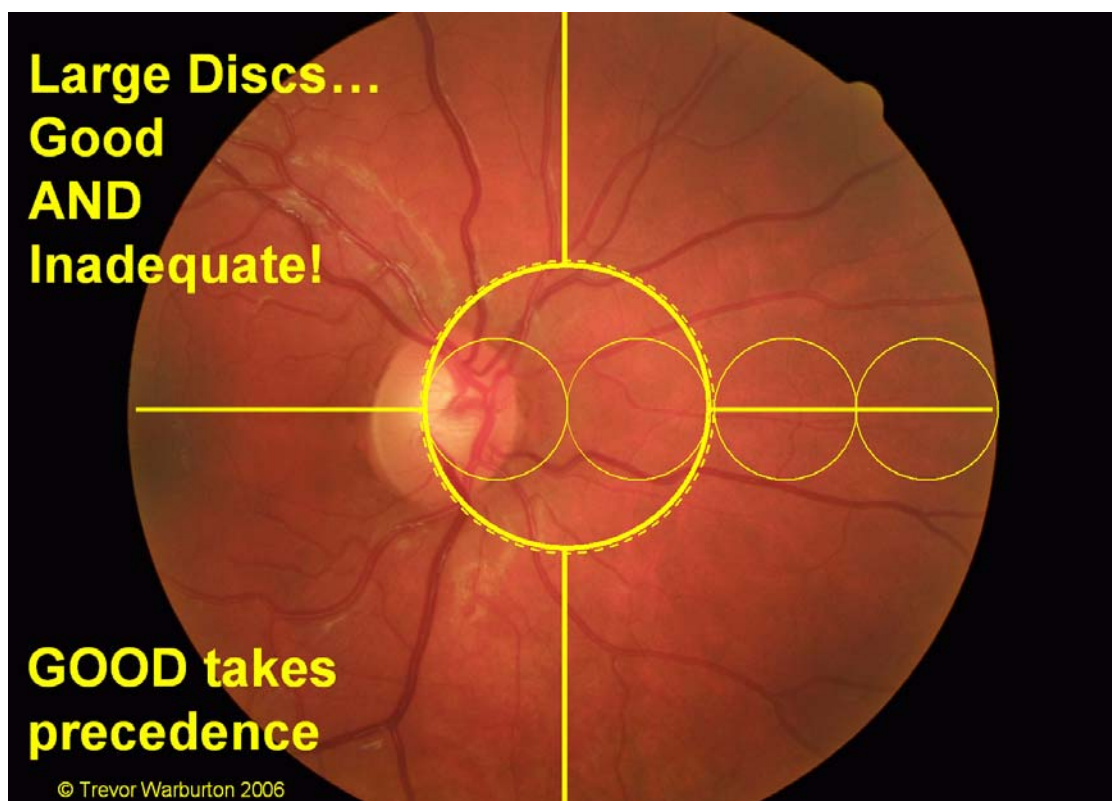
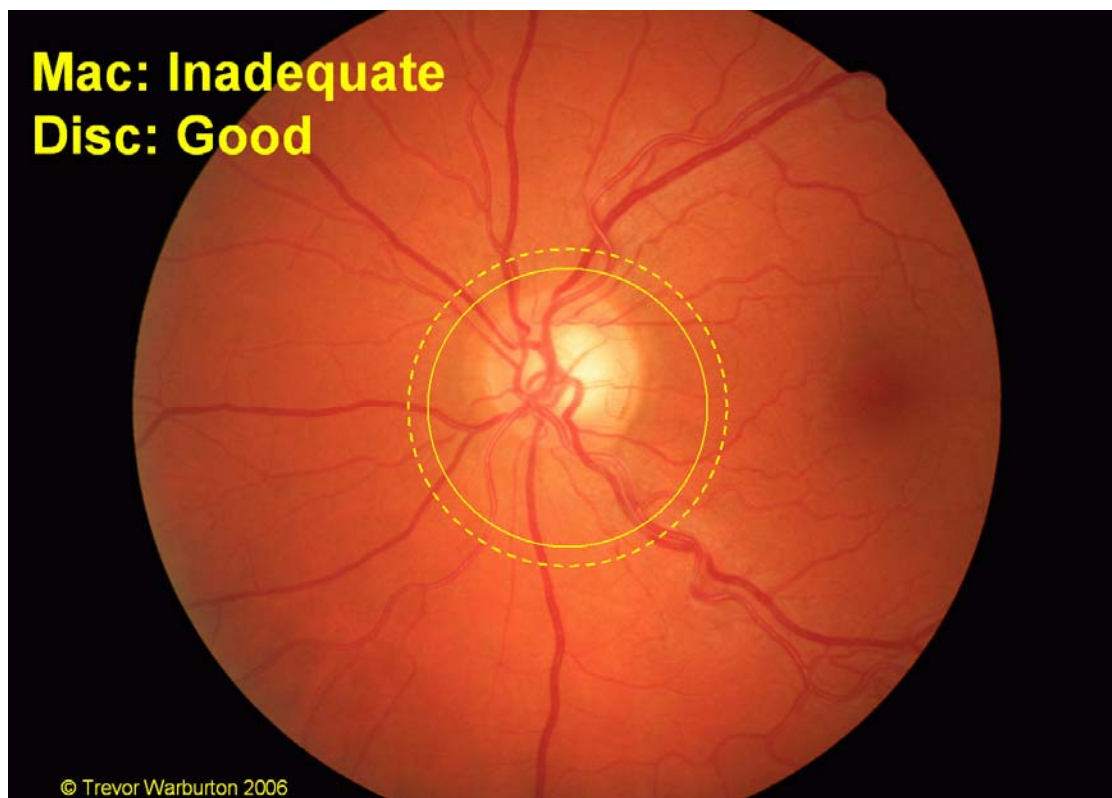
1. Use the auxiliary plus lens and the camera in the initial external eye view position. Focus by eye on the monitor and take the picture. These can be difficult to judge for focus and are often less than sharp



2. Wind the focus to its extreme position, switch the camera to fundus view and then move the patient back. Either place your hand over the top of the brow rest and push the patient's forehead back, or ask the patient to make a fist and place it between their forehead and the brow rest. You should now find the external eye close to being in focus. With most cameras you can now see the split focus bars against the iris or upper lid. Align these using fore and aft movement and the image should be in good focus. You may need to increase the flash intensity due to the increased range. This method usually results in sharper but smaller pictures and is the method used for the photograph reproduced here.







## 4. Protecting the System

Threats to computer systems take a number of forms:

**Virus threats** are well known and can replicate and distribute themselves via email, internet and removable storage media. Some viruses are relatively benign, whilst others can trash your hard drive. The protection is to use anti-virus software.

**Hackers** aim to gain access to your computer and its files. Their purpose may be to steal data or it may be to use your system to propagate software threats to others. Firewalls protect against access to your system

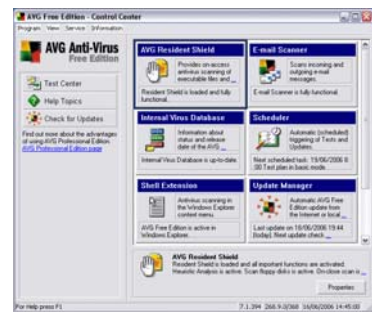
**Spyware** is used to gather information from your system, possibly without your knowledge. Anti-spyware can scan your system for these “data-mining” programmes, amongst others

**Data loss** is a problem and may be caused simply by a hard disc failure or file corruption. You should protect yourself by making regular backups of data.

**Anti Virus software** is available from many suppliers and some versions are free for personal (non-business) use.



You should ensure that your chosen product is set to update itself regularly and automatically. It should routinely scan your system as well as monitoring incoming email and internet downloads. McAfee, Norton and AVG are all well known suppliers of anti-virus software

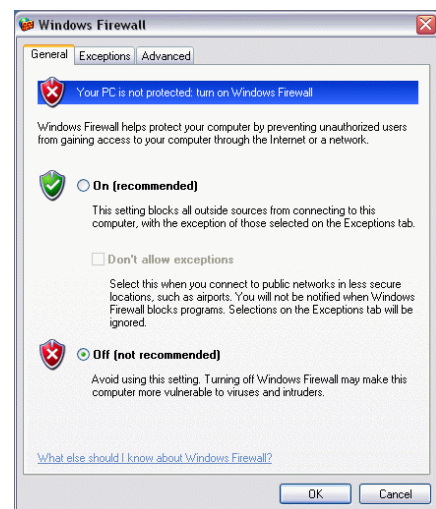


**Firewall software** can be stand alone, or may be



stand alone, or may be integrated into a security suite along with anti-virus software. Again there are free versions for personal use from some suppliers. Zone Alarm, McAfee, Norton are well known sources of firewalls, but there is a basic version integrated into Windows XP – the Windows Firewall.

At the very least, ensure that this is switched on, unless you have alternative firewall protection. You will find it in Control Panel, accessed from the Start menu. Some Firewall/Antivirus packages can considerably slow down a PC. If this happens, do not disable the protection, remove the offending software and use a different make.



**Anti spyware** may once again be a part of a security suite, although many of the stand alone products are free for personal use. Automatic updating and automatic scanning is less common with this form of software, so you may need to remember to run it from time to time. Spybot and Ad-Aware are 2 well known products, whilst Microsoft

has a Beta version of their own Windows Defender anti-spyware available for free download. Spybot, Spywareblaster and Defender all provide varying degrees of continuous protection to try and stop your computer from becoming infected in the first place – rather in the way anti virus software works.

**Windows Security Centre** was introduced with Service Pack 2 for Windows XP. It can be found in Control Panel under “Security Centre”. It monitors your computer for active anti-virus and firewall software, regardless of make, and also allows you to change the Windows automatic update settings. This latter should be set to automatically keep your computer up to date with Windows security patches and other updates.



**System Restore** is a Windows utility which monitors changes to the operating system and can roll back changes if, for instance, the installation of a particular piece of software has caused instability. It can be found as one of the tabbed section under System in Control Panel. Ensure it is turned on.

**What to Choose?**

Some of these products have been reported to consume a lot of computing power and slow the system down, whilst others can create technical issues. If you do not feel technically minded, then using Windows own firewall and AVG for virus protection is a simple and straightforward solution which uses a minimum of computing power.

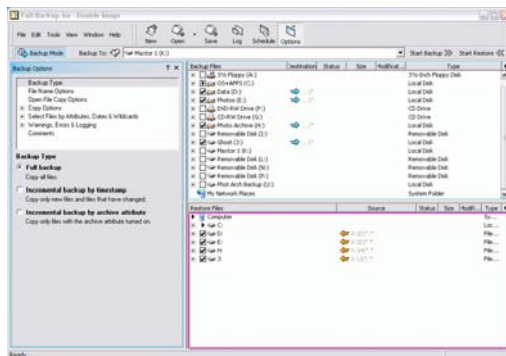


## 5. Backup

It isn't a question of whether you will have some sort of computer failure that causes a loss of data, simply a question of when. It is therefore vital that an up to date backup of any important data is available. How would your business survive if all your recall data was lost? Common media for backup are tapes and external hard drives. Tapes tend to be slow or expensive, but can cope with very large amounts of data and are easily taken off-site. Hard drives can have a large capacity, but are not often pocketable. Recently, an external hard drive with a removable cartridge has become available – the **Iomega Rev Drive**. This is suitable for a small practice and provides a capacity of 35GB at a cost of around £250 for a drive and 5 cartridges. Use a different cartridge every day and ensure the most recent backup is taken off-site.



Software is a question of personal choice. Tape backup and hard drive backup often use different software. Some backup software puts all your files into a different file “container” meaning it is not easily accessible without the backup software that created it.



**Double Image** is a simple to use piece of software for backing up to hard drives. It simply replicates the files and filing structure so that the backup up drive can be plugged into any computer and the files accessed without special software. Cost is \$49 (download from the USA [www.hostinterface.com](http://www.hostinterface.com)).

The programme is simple to use and allow easy automatic scheduling of backups. You can let the backup run in the evening (15GB takes about 25 minutes over a USB2 connection) and then change the drive the next day.



**Norton Ghost** and similar programmes provide a slightly different sort of backup. These do create their own file “container” but are a clone of the particular drive being copied. Most simple backups do not allow a boot drive to be copied and restored. Ghost allows the C-drive to be copied and easily restored in the event of a catastrophic Windows crash. The latest version can be configured to automatically take a snapshot of your C-Drive every day.

Many recent computers support RAID, which allows a second hard drive to be maintained as a mirror image of your main drive. In the event of a hard drive failure the system will swap automatically to the surviving disc and will warn you of the need for a replacement. With hard drive prices being so low these days this should be a must in any new system.

## 6. Assessment of Unit 06 – Imaging the Eye

There are 3 parts to the assignments required for successful completion of this unit.

- A.** Write short notes on the following questions.
1. Describe the field position/s used in your National Screening Programme.
  2. What factors might cause the operator to take additional retinal images in addition to the required fields during the patient investigation?
  3. What are the criteria for assessment of images for gradability according to national standards?
  - 4a. List ocular and non ocular factors which may prevent the operator from obtaining retinal images of suitable quality or quantity?
  - 4b. How would you attempt to overcome these reasons and document the reason?
  - 5a. What are your National targets for the acceptable number of ungradable images in an individual screening programme?
  - 5b. Give **two** implications of an unacceptable number of ungradable images.

Your completed work should be no more than 1000 words.

- B. Practical Demonstration** to the satisfaction of the workplace assessor during a clinic(s) with a **minimum of 6** patients, to include the following actions:

- Ensure that the environment is safe and suitable for the screening episode.
- Confirm equipment is working correctly.
- Access and open the appropriate software application.
- Open/initiate/confirm a new visit session for the patient.
- Meet and greet and seat the patient at the camera.
- Correctly use the external and if appropriate internal fixation device(s).
- Assess image quality. Follow National protocols if the image is ungradable.
- Obtain images of the patient's fundi (as required by the screening programme).
- Obtain fundus reflex images of both eyes (according to National protocol).
- Save the images and complete the session.
- Warn patient regarding post flash visual problems and glare.

- C.** Provide a **Practice File** containing appropriate digital, retinal and anterior segment images. The file should contain images obtained from no less than 6 people (both eyes) ideally with diabetes. Where possible, all of the patients should have been imaged during a single clinical session (i.e. 3-4 hours duration).

- **all** of the images should meet individual National quality requirements for gradability, and the images from no less than two of the participants (both eyes) must be fully assessable for clarity and correctly positioned according to their National protocol.

The Practice File must include at least **one** person from each of the following categories:

- A person with diabetes whose pupil(s), after adequate pharmacological dilatation (waiting no less than 30 minutes) are still less than 6mm diameter.
- A person with diabetes in whom there is visible central nuclear sclerosis, cortical or
- posterior subcapsular cataract on/near the optical axis in at least one eye.
- A person with diabetes who is over the age of 70 years.
- A person with diabetes who is of ethnic origin other than white Caucasian (e.g. Afro-Caribbean, Asian sub-continent).

In the first 2 categories (poor dilatation and media opacity) both digital retinal and anterior segment images **must** be included.

**Learners should note that in order to complete this file, images of up to 10 people from more than one session may be required.**

### **General points on future assessments**

For the written work you will be given guidance on what is required and deadlines for submission. The various written tasks will be deliberately spread out so as to minimise the workload. They actually aren't that difficult or lengthy for someone with the background knowledge of an optometrist. They may take a little longer for clinical assistants.

To try to minimise disruption to practices and to avoid taking practitioners out of practices during the working day, the assessments will be carried out in each practice using your own patients. This will require a programme of visits which will obviously take some time to carry out. You will be given plenty of notice of a planned visit to your practice and, so far as possible, the day of the week will be arranged to suit you.

There will need to be assessments in a number of subjects besides imaging; slit-lamp BIO and image grading are others. It will make sense economically for everyone if this is all carried out in one visit. This will require co-operation and careful planning on the part of the practitioner. As can be seen from section C, there will need to be a minimum number of patients with diabetes seen in the session, and it would be wise to allow for DNAs. Whilst it may seem a pain to have to book maybe 6 or more diabetics in one day, it is important to keep this in perspective. This should only be required once and is much better than having to come out of the practice. These are all patients that you will see at some point anyway. It should be easy enough to allocate a day and then have your staff direct all diabetic patients to that day (or even ring them and book them in). Most patients are happy to help if given a brief explanation. When the time comes we will help with advice on booking arrangements and explanations to patients.

## References:

National Screening Committee  
DR Screening website  
[www.nscoretinopathy.org.uk](http://www.nscoretinopathy.org.uk)

Fundus Camera Specification  
[www.nscoretinopathy.org.uk](http://www.nscoretinopathy.org.uk) → Digital Imaging → Camera spec.

City and Guilds  
[www.cityandguilds.com](http://www.cityandguilds.com)

Digital Camera back details  
[www.dpreview.com](http://www.dpreview.com)

## **Finally**

If you have any questions on general aspects of imaging the eye, please feel free to contact me.

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For queries relating specifically to the Cheshire screening programme you should contact Lyndon Taylor, who can also answer general imaging and cameras questions.

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**Trevor Warburton** is an optometrist in practice in Stockport. He has long had an interest in photography, both film and digital. He has acted as a consultant to the National Screening Committee on fundus cameras and digital imaging for several years and was very involved in drawing up the current NSC fundus camera specification as well as in assessing cameras.