Routine eye examination

Part 7 – Subjective refraction

Bill Harvey and **Andrew Franklin** continue their series looking at the eye examination. Here they describe the subjective refraction of the patient. **Module C9038, two general CET points**

Retinoscopy completed (see *Optician*, April 11), we can proceed to the subjective stage of refraction. In an ideal world, what you now have in the trial frame is the patient's full spectacle correction plus your working lens.

The accurate correction of the astigmatic error requires that the circle of least confusion (CLC) is placed on the retina and kept there while the cross-cylinder is in use. If this is not achieved, both the axis and power found will be wrong. The range of spherical powers which allow maximum acuity can be several dioptres in patients with small pupils and low acuities, though it is usually smaller. There may be a unique value for the correction which gives maximum contrast, although where accommodation is active this may also be a range. In this latter case the most positive lens that gives maximum contrast is usually the optimum correction.

The recommended routine includes a rather elaborate sequence of checks on the sphere power before, during and after the cross-cylinder is used. This is to ensure that:

- The patient has not been under-plussed. This is particularly easy with young patients, especially hyperopes
- The initial sphere will be within the effective range of the duochrome test.

Binocular versus monocular refraction

It seems remarkable that more students of optometry enter their pre-registration year performing monocular refractions than binocular ones. Some university clinics appear to take the view that monocular refraction is easier to learn, which seems a little patronising when applied to honours degree students. Binocular refraction has no disadvantages when compared to monocular refraction, though there are patients who cannot be refracted binocularly.

Advantages of binocular refraction

- Accommodation is suspended with a plus sphere, and tied to convergence
- No separate binocular balancing is needed. This saves quite a lot of time
- Where latent nystagmus is present, it will be reduced
- Rotational phorias (cyclophorias), if present, will not reduce the final binocular VA. This is now known to be an important factor in refractive surgery patients, and binocular refraction is required in the clinical protocols for pre-treatment refractions in some refractive surgery clinics.

Limitations

Binocular refraction should not be used where acuities are markedly unequal, or one eye is strongly 'dominant'. If you do start to apply it to an unsuitable patient, they will usually tell you fairly quickly ('Should I be seeing double?').

In such cases occlude the better eye, refract the worst eye. Then refract the better eye with the worst eye fogged, if necessary, or even unfogged if the acuity is considerably worse that the eye you are going to test. If the worst eye is 6/9 or less, it may be unnecessary to fog it. If the difference is less, it is often possible to refract binocularly, but the final decision has to be taken on an individual case basis.

Humphriss immediate contrast technique (HIC)

This method employs a fogging lens before the eye which is not being refracted. Humphriss recommended a +0.75DS lens, though most practitioners use a +1.00DS and some have used their retinoscope working lens (namely, +1.50) and claim it works as well. The idea is to reduce the acuity in this eye to about 6/12 at which point central vision is inhibited and the 'physiological septum' is established. The first eye is then refracted. When the end point is reached, the eye which was fogged is occluded, and the eye which was refracted is fogged by +1.00. Provided that the +1.00 blur test reduces the acuity to a satisfactory level, it can be left in as the fogging lens while the second eye is refracted. If the +1.00 does not reduce the acuity enough, add more plus until it does.

The 'Hack Humphriss' technique

This is one of those terribly useful and commonly employed techniques which never seem to find their way into the textbooks. However, it works so well that many practitioners use it as their basic technique. Essentially, this is a mixture between binocular and monocular refraction.

- To refract the right eye, occlude the left eye
- Refract the right eye monocularly
- Apply the +1.00 blur test. If the VA is reduced to 6/12 or so leave the +1.00 in. If not, adjust the fogging lens until it does
- Refract the left eye with the right eye fogged, that is binocularly
- Apply the +1.00 blur test to the left eye
- Check the final sphere balance of the right eye binocularly with the +1.00 still in place before the left eye.

If you need to add a substantial amount of plus because your retinoscopy result was some way out, it is worth checking the fogged eye periodically to ensure that it is still fogged. Sometimes, the addition of plus to the eye being refracted will cause both eyes to relax accommodation.

To place the CLC near the retina

Initially, we must determine the 'best vision sphere' (BVS), which can be defined as the most plus or least minus lens with which the patient can enjoy maximum visual acuity. In order that we do not under-plus, a 'fogging' technique is used. For each eye:

- Check the visual acuities with the working distance lenses still in place. The visual acuity should be around 6/24 for a working distance of 66cms and a working lens of +1.50DS. If the pupils are small the acuity may be considerably better than this.
- Reduce the plus to give 6/18. At this point you should be about +1.00 overcorrected.
- Reduce the plus until the VA stops ▶

improving (as opposed to going smaller and darker).

To refine the best vision sphere (BVS)

The sphere may be refined by use of the duochrome or ± spherical twirls. The two methods give statistically identical results, though this does not mean that they will always agree on a particular patient. Using one method to validate the other is generally a waste of time. Each method has some limitations and the techniques must be applied correctly. It is important that you are in control of the patient's accommodation and don't stimulate it unnecessarily. Change plus lenses by inserting the replacement before removing the original; change minus lenses by removing the original before inserting the replacement. This goes for cylinders as well as spheres.

Duochrome

- If the error is over 1.00D, or the vision 6/9 or worse, the results may be unreliable. The red and green only have a 0.50D difference in focus
- Over 55 years of age, the chromatic aberration of the eye drops markedly, so the dioptric interval of the red and green reduces, especially with a small pupil
- Yellowing of the lens causes a red shift, leading to under-plussing
- It is important that the patient understands that they must compare the rings on the duochrome rather than the colours themselves. Some patients concentrate more on the brightness of the rings, others on the basis of favourite colours
- If the rings on the green are clearer the answer is unambiguous regardless of the patient's age. If they are clearer on the red, the patient may be myopic or they might be accommodating. To avoid overdoing the minus, patients who see the rings on the red as clearer more often than seems right should also be checked with the other methods below.

Simultan technique (using ± twirls)

- The plus lens must be presented first for at least a second to relax accommodation.
- The negative lens should not be held for more than 1 second, which is the reaction time plus response time for accommodation.

The patient is asked 'Is it clearer with the first lens, the second lens…or are they both the same?'

It is useful to split the two halves of this question to avoid asking a multiple question. The initial comparison should be between more plus and more minus. The third option should only be offered if the patient cannot differentiate between the first two.

Figure 1 Cross cylinder

If the first lens is clearer or they are both the same, add +0.25. If the second lens is clearer (as opposed to just smaller and darker), add -0.25 to the eye being tested.

The rapidity with which the negative lens must be withdrawn can cause problems when a patient is slow to react. For this reason many practitioners have modified the simultan technique to eliminate this phase.

Adding plus only

After initially determining that the sphere is a little (not more than 0.50DS) under-plussed by duochrome or simultan, +0.25 is introduced and the question asked: 'Is it clearer with the lens, without it…or just the same?" OR 'Is it just the same with the lens, or worse?'

The first variant has the disadvantage of being a multiple question. The second may confuse because the +0.25 often is clearer (especially in presbyopes). You must, as always, pick the question to suit the current patient and it is sometimes necessary to change the question once you have got used to the patient. If in doubt, try both variations in succession and see which one the patient responds to best.

If the patient finds the vision clearer or identical with the plus, add +0.25 to the sphere and repeat. If the patient rejects the plus, add -0.25 to the sphere in the trial frame, then repeat.

With this method we may induce accommodation when we add minus power to the sphere in the trial frame, but we are always adding plus, and therefore relaxing accommodation, immediately before the comparison is made.

Placing the CLC on the retina

If the human visual system had no depth of focus, we could use the best vision sphere as it is and proceed to investigate the cylinder. However, there is a measurable depth of focus even in young patients with big pupils. On older patients with smaller pupils, and on the very astigmatic, whose principal foci will be widely separated, this depth of focus will be larger. Theoretically, the best way to ensure that the CLC is placed precisely on the retina is to allow the patient to put it there with accommodation, assuming they have any. There is actually no real scientific proof that patients do this, and the total amount of blur is higher at the CLC than at other points, but proceeding on this assumption seems to work. We aim therefore to allow the patient to accommodate minimally by slightly underplussing them.

For patients who are likely to have a small depth of focus (young patients with low degrees of astigmatism) modifying the BVS by -0.25 is appropriate

For patients with higher degrees of astigmatism or larger depths of focus a larger initial modification may be required.

Cross-cylinder technique

The cross-cylinder is a lens that has a positive cylinder worked on one surface and a numerically equal negative cylinder on the other. The axes of the two cylinders are at right angles to each other. Thus the actual power of a ±0.25 cross-cylinder is equivalent to a spherocylindrical lens of +0.25D spherical and –0.50D cylindrical power. In general, the axes are marked with + and – signs, and usually the plus axis marked in red and the minus axis in white.

Once you have refined the sphere, there is nothing to stop you checking the VA, as this might indicate how much cylinder remains to be corrected. In general, you will probably have close to the right correction (the 'working cylinder') in place, but where the astigmatic error appears small on retinoscopy, it may save time to leave out the cylinder entirely and check initially with a cross-cylinder of a power roughly equal to the estimated astigmatic error over a purely spherical correction.

Once the working cylinder has been established it can be refined as follows:

What should the patient look at?

Generally, the target should be circular and a little bigger than the smallest letters that can be seen, as targets containing linear elements may prejudice the result if the circle of least confusion is not quite on the retina. Some practitioners have advocated

using several letters at a time, but this can confuse the patient (not to mention the practitioner) when 'some letters are better with position one, and some with position two'. Circles or Landolt Cs of the appropriate size, or targets consisting of a pattern of dots, are preferable to single letters (other than 'O's).

Axis

- The cross-cylinder is presented so that its plus and minus axes lie at 45 degrees to the axis of the working cylinder
- The cross-cylinder should be presented for at least one second in each meridian, and spun as quickly as possible between meridians. Some cross-cylinders have flat areas on the handle to assist this
- Initially, a cross-cylinder of similar or slightly less power than the estimated required cylinder power is ideal. The axis is further refined after determining the power. For large errors of axis a ±0.50 gives a larger difference in image. As the error gets smaller, the ±0.25 gives similar differences but the overall blur and distortion are smaller and less distracting.

Power

- In this case the axes of the cross-cylinder are aligned with that of the working cylinder
- To check the result, use a bracketing technique by using the cross-cylinder on lenses which are + and –0.25DC from your end point
- Remember to modify the sphere when you change the power of the cylinder to keep the circle of least confusion on the retina. As a general rule, every cylinder change should be matched with a change of sphere by half the amount and with the opposite sign (that is for each -0.50DC, change the sphere +0.25DS). Alternatively, you can check with the duochrome or sphere twirls at intervals. Automated refractor heads modify the sphere automatically. Trial frames rarely remember to change the sphere for you, so that will be your job.

Final axis determination

- Recheck the axis with a ±0.25 cross-cyl. Bracket the end point by checking at 5 degrees either side of the axis found.

What if the patient can't make up their mind?

This may be because they don't understand what they are supposed to be doing. This may be because your instructions are not very explicit, or simply because they can't hear you. Repeat the instructions slowly and clearly. If they can both hear and understand you it may be because the cross-cylinder you are using is of insufficient power to make a discernible difference to the target.

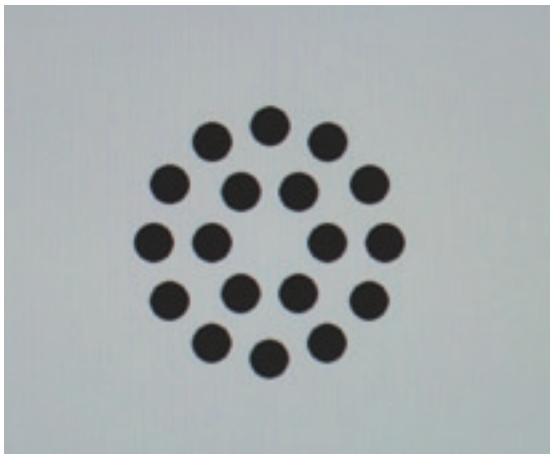

Figure 2 Suitable target for cross-cylinder technique

What if the patient always says position one is clearer?

'Perseveration' can be defined as a tendency of organismic activity to recur without apparent associative stimulus. This is the one track mind; the patient who keeps telling you that the first lens is clearer when you know it can't be. Perseverators may also give lower scores on some stereotests due to their inability to adapt.

To counteract perseveration the following strategies may be useful:

- Try to arrange it that the answer to any subjective test that you do is not the same too many times in succession. The use of bracketing techniques is beneficial
- In some cases, vary the question or the way you phrase it, for example, 'Is it clearer with three or four/five or six/seven or eight' and so on
- A contrived interruption, such as dropping a pen, may break the sequence. A regular rhythm of question and answer, while often useful with other patients, may only reinforce perseveration.

Fan and block technique

Most, though not all, tests charts have a fan and block at the top. It is a useful test to have, especially for those patients who do not respond well to cross-cylinder. It may actually control accommodation better than the cross-cylinder technique as a fogging technique is employed. However, it is thought to be less accurate than the cross-cylinder technique for small astigmatic errors, and it is a monocular method. The starting point is the best vision sphere as with cross-cylinder, but then the techniques diverge.

- Occlude the LE (usually the RE is tested first, for no particular reason)
- Remove the cylinder from the RE
- Check the visual acuity
- Add + until this drops by one line and the circles on the duochrome are clearer on the red
- The patient then looks at the fan and is asked to report which line(s) are clearest. Initial selection can be aided by asking, 'If this was a clock face, what time would the clearest line be pointing to?' The clearest line, or the centre line of a group of clear lines, indicates the negative cylinder axis
- The axis can be refined by using the arrowhead. Rotate the arrow until it points towards the chosen clearest line and adjust the axis until the two arms of the arrowhead appear equally clear
- At this stage one of the blocks should be clear, while the other one, which has lines at right angles to the clear one, will be blurred. Add negative cylinder until both blocks are equally clear
- If all of the lines in the fan seem equally clear to the patient, increase the fogging lens by a further +0.50D and check again. If the lines are still all equally clear, no significant astigmatism is present
- Reduce the fogging lens to find the best sphere, then repeat for the left eye.

Final sphere check

- If your spherical power was correct when using the cross-cylinder, the patient should be slightly under-plussed. Therefore there is no logical reason to offer more minus to the patient. If the patient needs more minus at this stage, your cross-cylinder has probably got the cylinder wrong, so you would need to check it again
- If using the duochrome pre-presbyopes are often best left on the green, presbyopes on the red, but there are exceptions. If in doubt, balance equally
- Young myopes are often used to being slightly overcorrected, and young hyperopes under-corrected
- Exophores may be happier on the green, as accommodative convergence may help to compensate their phoria. Esophores may be better with more plus
- Use a +1.00 blur test. With the other eye occluded, the VA should be 6/12 or 6/18, with an average pupil. If it is, you have the physiological septum in place for the other eye if you wish to check the sphere balance binocularly. If it is better, the patient is probably under-plussed, unless they have small pupils.

The above points are valid for a 6m chart. In practice, you may come across projection charts which may present an image at 3m, or at infinity. When ▶

working with infinity charts you need no adjustment of the sphere for the testing distance. Direct 6m charts should in theory cause over-plussing of 0.167D, which is why pre-presbyopes like to be left on the green. Presbyopes usually have smaller pupils, giving greater tolerance to blur, and appreciate the slight boost to their mid-distance vision that the extra quarter-dioptre gives. Projection charts with a 3m distance will cause over-plussing of 0.33D, so it is customary to add -0.25DS to the distance portion of the subjective findings before prescribing. In the case of a presbyope, any extra minus on the distance prescription should be offset by adding +0.25DS to the reading addition.

'Binocular balancing'

In older textbooks methods are described whereby the eyes are fogged and the sphere adjusted to give equal acuities in the two eyes, but this is rather missing the point of it all. Many patients have a 'better' eye, and if we artificially equalise the acuities the patient may be uncomfortable. It may only be possible to equalise the two by compromising the acuity of the better eye.

The idea of binocular balancing is to balance the accommodative effort in the two eyes by uncovering any extra hyperopia which becomes manifest when the patient is binocular. If the patient has no accommodation there is little point in trying to balance it. Some practitioners have advocated trying to balance the depths of focus of the two eyes, but this seems a little eccentric, given that the depth of focus is largely pupil-dependent.

Various methods have been developed to give each eye a separate target without causing complete dissociation, using either a physical septum placed on the chart or mirror, or polarisation.

The actual balancing can be done either using the duochrome, or by finding the most plus lens consistent with best acuity for each eye.

Where you have performed a binocular refraction, no separate balancing is required. In those cases where binocular refraction is inappropriate, it is unlikely that any of these techniques will give you any worthwhile information.

If all else fails, and the patient is happy, keep the balance the same as the last correction. A change of balance often requires some adaptation on the part of the patient, so it should not be undertaken casually. Some management of the patient's expectations is also required in such circumstances, to avoid unnecessary re-tests.

MULTIPLE-CHOICE QUESTIONS

1 Which of the following statements about binocular refraction is not true?
A It is better for patients with latent nystagmus
B It reduces errors related to cyclophoria
C It is better with strongly eye dominant patients
D It suspends accommodation well

2 What is the dioptric difference between the red and green targets on a duochrome target?
A 0.25DS
B 0.50DS
C 1.00DS
D 2.00DS

3 Which of the following statements about duochrome is true?
A Smaller pupils enhance the accuracy of the test
B The brightness of the colours is more important than the distinctness of the rings
C Cataract will tend towards favouring the rings on the red background
D Accommodation will favour the rings on the green

4 What is the actual power equivalent of a +\- 0.50D cross-cylinder lens?
A +0.25DS/-0.50DC
B +0.50DS/-0.50DC
C +0.50DS/-1.00DC
D +1.00DS/-1.00DC

5 Which of the following statements about fan and block technique is true?
A It is more accurate than but slower than cross-cylinder technique
B It is a monocular method
C It is better for larger cylinder powers
D It is not suitable for presbyopes

6 Assuming cross-cylinder has been performed accurately, what should be the state of the mean sphere?
A Slightly under-plussed
B Slightly over-plussed
C Exact
D Heavily over-plussed

7 What should be the acuity for a 6/6 patient through a +1.00DS lens and an average pupil size?
A 6/9
B 6/12 - 6/18
C 6/24- 6/36
D 6/60

8 Which of the following is true about exophoria?
A Exophores prefer more plus to esophores
B Exophores are best left on the red
C End sphere for exophores should tend to minus
D Exophores and esophores should not be treated differently

9 For a cylinder change of -1.50DC during cross cylinder, by how much should the sphere change?
A +0.75DS
B -0.75DS
C +1.50DS
D -1.50DS

10 What fogging lens was recommended by Humphriss for his immediate contrast technique?
A +0.50
B +0.75
C +1.00
D +1.25

11 Why might the +1.00DS blur test give less than reliable results in an elderly patient?
A Elderly patients will not understand the test
B Light scatter is enhanced by the fogging lens so giving worse acuity than predicted
C The small pupil increases depth of focus and makes end acuity better than predicted
D Macular changes reduce blur sensitivity

12 What is the aim of introducing -0.25DS prior to cross-cylinder assessment?
A To ensure patient appreciates the duochrome
B To improve the acuity
C To stimulate accommodation
D To allow the patient to place the circle of least confusion on the retina by accommodation

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Binocular plus

With the patient fixating binocularly, check if +0.25DS is accepted binocularly. If it is, you may incorporate it into your final Rx, but allow for testing distance, binocular balance and so on. Using binocular refraction techniques, it is rarely necessary to add binocular plus, but practitioners who use monocular techniques may benefit from this step.

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