

Considering ocular motor balance in dispensing

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Competences covered:

Dispensing opticians: Optical appliances, Refractive management
Optometrists: Optical appliances, Binocular vision



Ocular motor balance (OMB) can be regarded as the relative alignment of the visual axes in relation to the achievement of binocular single vision (BSV). As defined by the GOC core competencies for Dispensing¹ 7.1.5, the dispensing optician should "understand the investigation and management of patients with an ocular motor imbalance" – and competency 4.1.1 "identifies anomalies in a prescription and implements appropriate course of action – offers solutions for example, aniseikonia, anisometropia". (This wording is exactly the same as for Optometry 4.1.1)².

This article, using case studies, aims to remind readers of some basic binocular vision theory and its relevance to dispensing.

During a routine eye examination, although the exact format and

content will be determined by professional judgement and minimum legal requirements, an assessment of habitual OMB is regarded among the list of what a full eye examination should include³. However, more detailed attention may be given to measure a patient's OMB with regard to certain symptoms, but also to refractive changes that might bring about a change in the OMB, whether due to subtle chronic changes (e.g. myopic shift in nuclear cataract) or often more sudden changes due to cataract surgery and implant, where the refractive change may be greater but 'permanent'.

With an ageing population there are more patients with refractive changes due to incipient cataract, and by definition more 'successful' cataract extraction and implants are performed. Increasingly perhaps, only one eye has been operated on, and

the criteria for the second eye may mean a considerable period of time where a large anisometropia is present. The optical dispensing options may now, even more, need that expertise knowledge that has been rigorously tested in professional qualifying examinations.

Binocular single vision (BSV) and heterophoria

The perceptual co-ordination to produce BSV that takes place in the brain is primarily the ability to fuse slightly dissimilar retinal images, which itself requires to be maintained through vergence eye movements. When a pair of eyes are viewing an object, the visual axes are maintained due to the desire for BSV – and this driver is stronger than the desire for visual clarity. This is brought about by the six pairs of oculomotor muscles and constant feedback via the three pairs of cranial nerves devoted only to this

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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 10 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 April issue of *Dispensing Optics*. The closing date is 14 March 2015.



C-37719

Deviation	Axis	Classification	Angle > near	Angle > distance
Temporal	Vertical	Exophoria	Convergence weakness	Divergence excess
Nasal		Esophoria	Convergence excess	Divergence weakness
Upwards	Horizontal	Hyperphoria	Tend not to differ much on viewing distance but may be more noticeable for critical tasks	
Downwards		Hypophoria		
Wheel rotation temporally	Sagittal	Excyclophoria	Tend to be rare	
Wheel rotation nasally		Incyclophoria		

Table 1: Classification of Heterophoria

function. The fusional reflex can be considered to maintain the visual axes; hence the eyes are in an active position. Disrupting fusion will cause the eyes to take up their passive position.

The concept of orthophoria, where the active and passive positions are the same is an ideal rather than the norm. The combination of the position of the eyes and viewing objects at different distances and positions in space means that the visual axes show a tendency to deviate requiring constant adjustments. As this motor imbalance tends to occur, if BSV is mostly achieved then the imbalance is a heterophoria and measurable. The direction of the deviated eye from fixation allows a classification of heterophoria (**Table 1**). Although 80 per

cent of the population exhibit some degree of horizontal heterophoria⁴, and **Table 2** shows the values considered to be within normal limits, i.e. present but not necessarily causing symptoms.

The presence of heterophoria may be caused entirely by, or be exacerbated by, a number of factors, both anatomical (large PD, specific oculorotary muscle weakness, neurological defects) and uncorrected or poorly corrected ametropia and, of course, anisometropia, where an increasing differential prismatic effect may be encountered as the eyes view away from the optical centres of a pair of spectacles. However, patients often are symptom free as their fusional

reserves are adequate for the visual tasks undertaken (**Table 3**).

The fusional reserves are the maximum amount the eyes can converge (positive fusional reserves, measured with base out prism) or diverge (negative fusional reserves, measured with base in prism) while still maintaining BSV. As the image doubles, the break point is reached. Note from **Table 3**, both positive and negative reserves are greater for a near object and as convergence also stimulates accommodation, an image may become out of focus but still single (blur point). The vertical values shown in **Tables 2** and **3** are much smaller, suggesting a vertical differential prismatic effect is more likely to cause problems than a horizontal differential prism.

Continued overleaf

Table 2: Muscle Balance within normal limits

Distance	Exo 4Δ	Eso 4Δ	Vertical 1Δ	Cyclo 0Δ
Near	Exo 8Δ	Eso 4Δ	Vertical 1Δ	Cyclo 0Δ

Table 3: Fusional Reserves

Direction	Fixation	Blur Point	Break Point	Recovery
Convergence (base out)	Distance	4Δ	20Δ	12Δ
	Near	8Δ	30Δ	20Δ
Divergence (base in)	Distance		8Δ	4Δ
	Near		15Δ	8Δ
Vertical	Both		4Δ	2Δ

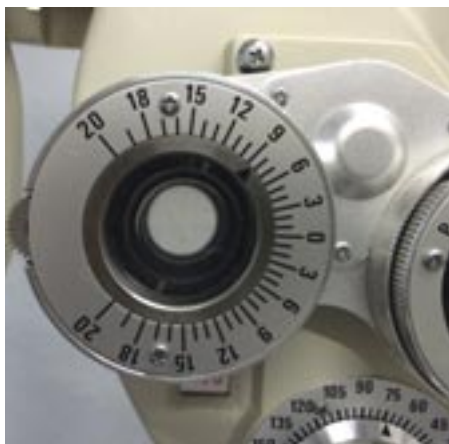


Figure 1: Rotary prism and prism bar

Fusional reserves can easily be measured in the test room using a rotary prism (often incorporated as part of a phoropter) or with a prism bar (**Figure 1**). Fusional reserves can often be modified (increased) in younger patients with orthoptic-based exercises, but also can be affected (decreased) by advancing age, general well-being, medication, alcohol and drugs. Add to this a changed refractive state and/or increasing the amount of certain critical tasks, e.g. increasing use of hand-held electronic devices such as tablets and smartphones, it is not surprising that some patients symptoms are directly related to a heterophoria present.

The role of fusion during OMB measurement

Different values of deviation can be obtained for the same patient depending on the way fusion is prevented in the clinical environment. Perhaps the most obvious way to prevent fusion, i.e. cause dissociation, is to cover one eye with an occluder (the cover test). The occluder is held

in front of each eye in turn and watching the recovery movement of the eye when uncovered in terms of direction, speed and magnitude. This can be measured accurately using a prism cover test, or estimated just by observation. This will also differentiate between a heterophoria (latent deviation) and heterotropia (manifest deviation).

The assessment of the speed of recovery movement is often a clue as to whether it is likely to be symptomatic and would be repeated with the patient viewing a distant and near object, or any relevant working distance. Further dissociating tests to obtain a measurement could include a Maddox Rod, high power prism or Maddox Wing (for near only), which dissociate by distortion, displacement or dissimilar object respectively (**Figure 2**).

BSV is based on corresponding retinal points and fusion, however, flexibility within the system allows for slightly disparate images to be fused providing they fall within Panum's

fusional areas. In heterophoria, advantage may be taken of this fixation disparity (FD) or 'retinal slip' to give partial relief by allowing one eye to deviate slightly from the position of accurate fixation. There are methods to measure this by partial rather than complete dissociation techniques, which usually reveal a smaller deviation in the same individual.

One example of this type of test is the Mallet Unit presented along with a distance test chart and a self-contained version used for near (**Figure 3**). This has orthogonally polarised targets and is viewed through a compatible polarising filter; other ways to achieve partial dissociation may include red and green targets and filters. This measured value of prism can represent the uncompensated amount of a total deviation and may be termed the 'associated heterophoria'.

Generally, if there is no measurable fixation disparity despite a measured latent deviation, it is described as 'compensated', even if the

Figure 2: Maddox rod and Maddox Wing

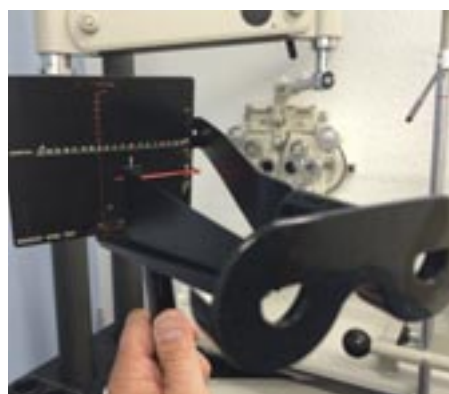
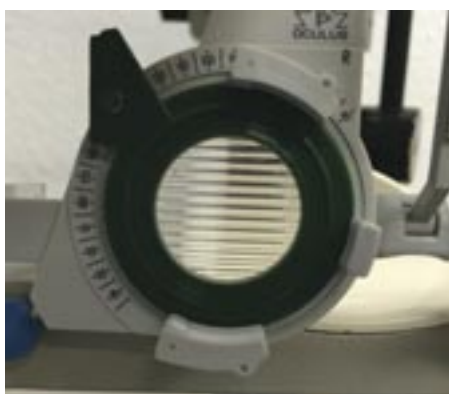


Figure 3: Near Mallet Unit



dissociated value is greater than 'normal' limits, and if this is the case, the patient is likely to be symptom free. If a patient does have symptoms, the value of the aligning prism is often the amount of prism that might be prescribed in spectacles, again rather than the full amount of the heterophoria present. The International Standards Organisation (ISO) has proposed that the term 'aligning prism' is adopted rather than using either 'FD' or 'associated heterophoria' as although their values may correlate, they are not strictly all describing the same entity⁴.

Dispensing

Often the symptom-relieving amount of prism is so small that it is regarded as a subjective result verses an objective result – the subjective result being the smaller amount of prism considered to prescribe. As described above, there are various factors that might mean a previously compensated heterophoria is becoming (or has become) decompensated, especially with certain symptoms, e.g. frontal headaches, asthenopia, blurred vision, refocusing difficulties and, of course, even manifest diplopia, especially when associated with certain visual tasks.

In analysing the patient's prescription, there are different areas that might challenge the conventional spectacle dispensing process. A really obvious issue was identified with the following patient. A 75-year-old male had a successful left cataract extraction and although he did have some developing lens changes in the right eye, his visual acuity was still reasonable. He was going travelling for some time so preferred to delay any further ophthalmic treatment until returning to the UK in six months' time.

His new spectacle prescription was now R -5.00/-1.00x85 6/9 L +1.00/-1.75x90 6/6 Add 2.50 each eye (R&L N5). The left eye was previously myopic as evidenced in his current unchanged bifocal spectacles. With approximately six dioptres of newly created anisometropia but an otherwise binocular patient who would prefer to continue with multifocal lenses, a pair of flat top 28mm bifocals



Figure 4: A Bi-Prism (slab-off) bifocal lens

were dispensed, the right lens as a bi-prism (**Figure 4**) (see also Case Study 3 below).

Three further case scenarios to present that represent the following:

1. Where a decompensated heterophoria has been identified and relieving prisms have been prescribed.
2. Changing (or introducing) a spectacle prescription, without regard to the patient's OMB.
3. Where a prescription reveals an unwanted differential prismatic effect (especially vertical), that is now causing (or is likely to cause) symptoms due to either a change in the prescription itself, or a change to the viewing tasks of the patient (or both).

These are all based on real patients that have been seen in a university eye clinic setting in the last academic year.

Case Study 1

Patient A: a 62-year-old retired female.

Routine eye examination, patient finding their separate spectacles increasingly frustrating as they are finding they now prefer to use their distance spectacles for TV, but enjoys knitting and some other close work related activities while doing this, and now using a tablet for patterns, etc. Previously they just managed their near task using their single vision readers and looking over the top for distance. As the patient had not been seen in the clinic before, their current spectacles were focimetered and optical centres (OCs) noted.

Current spectacles from two years ago:

- R +1.00/-0.25x95 L +1.25/-0.50x85 OCs 62, good condition. S/V plastic lenses
- R +3.00/-0.25x95 L +3.25/-0.50x85 OCs 52 S/V plastic lenses, scratched

Of note was the 'apparent' difference between the OCs in the reading spectacles and the patient's measured pupillary distance (PD) and near centration distance (NCD), which were 62 and 58 respectively. This effectively meant there was nearly 1.00Δ base in each eye at the NCD, so could this be an error in the making of these spectacles. The clue was they were (and still are) reasonably satisfactory from a visual point of view and the OMB findings.

As often happens, more of her latent hypermetropia has become manifest, hence the reason she now appreciates the small distance correction more. Her most recent findings are:

- R +1.25/-0.25x90 6/6 L +1.50/-0.50x85 6/6 Small exophoria on CT but no aligning prism on Mallett Unit
- R +3.50/-0.25x90 N5 L +3.75/-0.50x85 N5 large exophoria on CT 1.50Δ IN for each eye aligning prism on Near Mallett Unit
- Near range checked for habitual working distance

So it seems that the centration distance was probably correct, and that the base in prism was intentional, although the patient did not remember being told that 'prisms' were included when the spectacles were supplied. The simplest dispensing solution here would be to continue

with separate pairs with the prism provided in the near pair only. But this would not satisfy the improved distance vision and allow the patient to carry out the prolonged near tasks simultaneously.

Solutions in bifocal format to include prism in the segment would be⁵:

- Glass Solid Round 30mm Prism Controlled (prism segment) but no longer available
- Resin handmade bifocal (e.g. Presto from Norville)
- Franklin Split bifocal. This could be a solution for any of these scenarios but has the distinct disadvantage of comesis, time to manufacture and cost
- Increase inset using large flat top bifocal (e.g. 40 or 45mm segment diameter)

For this last solution, the total inset would be combination of the NCD requirement and the amount required to produce 1.5Δ with the add power being of +2.25D, i.e. $2 + 6.67 = 8.67\text{mm}$. Since there is also a very small amount of base out prism due to the distance portion, increasing to 9mm inset. As this uses conventional lenses, price could be a factor and it can be readily supplied in reasonable time. Patient A, having had the pros and cons of the various solutions explained, did opt for this one.

Case Study 2

Patient B: a 47-year-old male lecturer.

Early eye examination as the patient feels their spectacles seem 'too strong'. Supplied as their first pair for near, having previously been aware that near tasks had become more difficult and was using +1.00DS ready-mades. Had been back to original supplier but was told that spectacles were 'correct', requiring reading spectacles was 'normal' for their age and that they just needed to 'get used' to them. The patient had reverted to their off-the-shelf readers, which they felt more comfortable with for most of their tasks apart from close fine detail.

Current spectacles from approximately six months ago:

- R +1.75/-0.25x95 L +1.50DS OCs 60, good condition. S/V plastic lenses with coatings

Current findings:

- R +0.25/-0.25x90 6/5 L -0.25DS 6/5 PD/NCD 64/60 Amplitude of accommodation 2.00D

Using half amplitude in reserve, and based on 40cm working distance, an add of 1.50 would be an appropriate starting point, subjectively refined, and range checked, which is so similar to the 'rejected' spectacles. Sometimes patients are not aware of the consequences of a near addition and the artificial far point created, unless informed. But with a 1.50DS add, as in this case, the artificial far point (i.e. the focal length of the add power) would be 67cm, and so should not be the issue, although often becomes a problem with higher adds.

The OMB status of this patient revealed a near exophoria with the correction in place but absent without, using an accommodative target. The extra accommodative effort and associated convergence using the +1.00DS ready readers was providing the relief for the exophoria, and when the new increased add is used, the reduced accommodative effort meant the heterophoria was becoming symptomatic even though the actual print was clearer at the closest working distance the patient might use.

The two options in this case were:

- Give the full add and prescribe base in prism
- Give slightly reduced add (the patient needed some increase) and recommend appropriate orthoptic exercises (e.g. pen to nose type) aiming to improve positive fusional reserves

The second option was undertaken with a recommendation to review in three months' time. Some research suggests that the efficacy of eye exercises reduces with age, but other studies have shown success even within the presbyopic age group⁴. Obviously, this patient will lose more of their accommodation with time but if the eye exercises do improve the OMB then the prism option may not necessarily be inevitable. The dispensing 'issue' was only that the patient was a non-tolerance, but the

only action of a DO in this case would be to refer to a prescriber since the spectacles were found to be correct¹.

Case Study 3

Patient C: a 71-year-old retired female.

This patient was happily wearing bifocal spectacles supplied 18 months ago, but was noticing deterioration in vision in their right eye for some time. Distance vision almost seemed clearer now without spectacles. Prolonged reading has proved tiring for some time. Current spectacles from last examination:

- R +2.25/-1.00x30 L +3.00/-0.50x135 Add 2.50 R&L. OCs 58, reasonable condition, left lens scratched. Flat top 28mm bifocal lenses with coatings

VA's with current spectacles: R 6/12 and N6, L 6/9 N5. Calculating the vertical lens powers using the concept of notional power $F \sin^2 \emptyset$ (where F is the cylinder power and \emptyset is the angle between the axis and the meridian in question)⁶. This gives an approximate value but is very useful as an indicator (R +1.50 using $\frac{3}{4}$'s of the cyl power, L +2.75 using $\frac{1}{2}$ cyl power) at 10mm below the distance OCs would have a vertical differential of around 1.25Δ up LE. Could this be part of the near fatiguing from before? New Rx: R +1.50/-1.25x45 6/7.5 L +2.50/-0.50x120 6/7.5 Add 3.00 N5 R&L.

Ocular examination showed advancing nuclear sclerosis (cataract) especially of the right eye. This was causing a typical myopic shift, however, the patient really appreciated the improvement in distance vision especially with the right eye with the new prescription. The change would also increase the differential vertical prismatic effect to at least 1.50Δ, further exacerbating the prolonged near problem.

Vertical differential prismatic effect

Many patients who technically have amounts of vertical differential prism in their spectacles due to their anisometropia that exceed 1Δ, report no problems with their multifocals. This may be because their own vertical fusional reserves are above average, or often the visual acuity in one eye is reduced or the image is suppressed to the extent that fusion is irrelevant.

One way to explore whether the calculated differential prismatic at the NVP needs to be resolved, would be to place the patient's reading prescription in a trial frame along with a plano prism equal to the differential placed before one eye. Using a Near Mallet Unit (or similar), ask whether the markers are stable and aligned, and get the patient to undertake a typical near vision task for a number of minutes and check their subjective visual comfort (**Figure 5**). Repeat the near vision task without the prism and compare. Those reporting a subjective difference are more likely to benefit from some consideration of the problem.

Although there are a number of solutions to eliminate (or at least reduce) the vertical differential prismatic effect, some lend themselves better to certain types of prescriptions, assuming multifocal lenses are preferred. Different size round segment bifocals. The segments exert base down prism at the NVPs. This works well with +ve distance Rx's, small differential prism and high adds. Calculating the difference in segment sizes using:

$$d_1 - d_2 = \frac{(2 \times \text{diff Pv})}{\text{Add}}$$

where $d_1 - d_2$ is the difference in segment diameters in cm, would give segment sizes of 10mm to completely eliminate the differential prism. Just using a difference of 5mm would reduce the differential to less than 1Δ and be barely noticeable in appearance. The larger segment for the left to neutralise the unwanted base up. This would be a really good option but the patient was already wearing flat-top bifocals and it was considered the introduction of jump each time the visual axes crossed the dividing line might be an added complication.

Slab-off (Bi-prism). This is available for both bifocals and progressive power lenses. Traditionally, slab-off removes base down prism in the lower part of the lens, so works well with -ve distance Rx's, removing the unwanted base down from the more negative lens (**Figure 4**). However, this would be difficult in a +ve lens, so the process could be applied the surface mould, so when the mould creates the lens surface it effectively adds base down to the lens surface (this could be called 'slab-on'

or 'reverse slab-off'), and would be applied to the more positive lens⁷.

The patient was ordered a pair of CR39 flat-top 28mm bifocals as a bi-prism with 1.5Δ base down added. The transition created across the lens surface looks more like a faint horizontal crease than a solid line. Using freeform technology, the prism can now be added as well as subtracted to quite small amounts (less than 1Δ) and with a blended division making the transition unnoticeable, and using different lens designs, forms and materials⁸. Sometimes shorter corridor progressive lens designs can be considered for small amounts of differential prism to help keep the amount of prism encountered at the near visual point to a minimum.

Conclusion

Sometimes, and inevitably, most problems only manifest themselves in the form of a returning patient, having recently purchased their new spectacles, to complain that something is not right. Occasionally, the patient may not return to you but go elsewhere in the hope that some resolution is available, but probably not being very complimentary of their recent experience. Either way, it can be difficult at the point of dispensing to foresee a problem when perhaps that problem should have been identified during the prescribing process.

A skilled practitioner, whether normally working in or outside of the consulting room, should certainly be able to recognise the issue of differential vertical prism when it arises, and at least consider its possible effect. Careful questioning in terms of previous spectacles and symptoms, having identified a potential problem, it would be perfectly acceptable (and recommended) that it is explored further during the dispensing process.

Some studies have shown that 60 per cent of anisometropic patients benefit from some form of prism compensation, and that does not mean that the other 40 per cent would not notice the difference⁹. Being able to offer alternatives to just 'separate pairs' and knowing the status of a patient's OMB can prove invaluable when trying to find reasons for non-



Figure 5: Checking for visual comfort using Near Mallet Unit

tolerance. The role of the optical detective is both rewarding for patient and practitioner alike.

References

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Multiple choice questions (MCQs)

Considering ocular motor balance in dispensing by Stephen Freeman

1. How many pairs of cranial nerves innervate the ocular motor muscles?

- a. 6
- b. 3
- c. 4
- d. 2

2. Which statement best describes the term 'orthophoria'?

- a. It is where only one eye deviates when occluded
- b. It is said to exist when all negative fusional reserves have been used up
- c. The active and passive positions of the visual axes coincide
- d. A term synonymous with decompensation in heterophoria

3. Which statement is UNTRUE?

- a. For myopic presbyopes with anisometropia, base down prism can successfully be removed from the more negative lens to avoid vertical diplopia
- b. Where an eye deviates nasally it indicates esophoria may be present
- c. It is possible for slightly different retinal images to be fused if they still fall within Panum's fusional areas
- d. If a patient experiences no problems with vertical differential prism of 2Δ their vertical fusional reserves may be below average

4. Complete the sentence with the correct option. The term 'positive fusional reserves' in binocular single vision refers to...

- a. the maximum amount the eyes can converge measured with base out prism
- b. distance vision only
- c. hypermetropes who are able to converge to read without difficulty
- d. how much the eyes can diverge before the image doubles

5. A first-time bifocal wearer has the prescription:

R: +1.25/-1.00 x 180, L: +0.75/-2.75 x 180 Addition +2.75DS.

Visual acuities are 6/6 R and L and N5 just managed.

Which of the following would provide the best dispensing option to control vertical anisometropia?

- a. R R25 and L R40 segments
- b. R and L R28 segments as acuities are the same
- c. R R40 and L R25 segments
- d. R S45 and L S28 segments

6. Which statement is UNTRUE?

- a. Digital surfacing techniques now enable relatively small amounts of prism to be worked on a spectacle lens
- b. Fusional reserves may be increased by orthoptic exercises even where presbyopia exists
- c. 8 prism dioptres of esophoria may be present for near but unlikely to cause symptoms
- d. Deviation of an eye from fixating when occluded may be made worse by extrinsic muscle weakness

The deadline for posted or faxed response is 14 March 2015. The module code is C-37719.

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