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Myopia

Part 3: Assessment and correction

In the last in our three-part series on myopia, **Catherine Viner** considers the assessment and correction of myopia in practice. Module C15569, one general point for optometrists and DOs

The predominant symptom in uncorrected (or under-corrected) myopia is blurred distance vision.[1-3] It is suggested that because this symptom is so readily apparent, myopes account for a disproportionate number of those presenting for an eye examination.[4]

Therefore, being able to offer an individually tailored visual correction to those within such a large group of patients is extremely valuable. This article will explore the considerations to be made in order to provide the symptomatic myope with the most appropriate solution to his or her ametropia.

ASSESSMENT

Refracting and prescribing

Caution is recommend when subjectively refracting myopic patients, due to their tendency to accept excess minus.[4] A brief presentation and careful questioning when offering negative lenses is advocated, ascertaining that the extra lens definitely makes the target clearer and not just darker or smaller.[5] This is particularly important as it is often the case that once a patient has become accustomed to a slightly stronger negative prescription, they find it difficult to relinquish the extra minus.[4]

Werner and Press[6] point out that 'myopes have a right to their seeing preferences', indicating that a myopic patient may enjoy a slightly 'softer' view of the world. A newly presbyopic myope may indeed find it useful to be slightly under-corrected to facilitate adequate near vision in their distance spectacles.[7]

However, it is equally important to ensure that a myopic patient is not under-minused. If in any doubt about prescribing what appears to be a reduced amount of minus, it is recommended that the proposed new prescription be used to view a more realistic distance target than that of the test chart.[6] It can also be useful to leave a patient on the green on duochrome if they experience night myopia,[5] thus allowing a small amount of extra minus to be incorporated into the prescription. The poorer vision experienced due to the accommodation shift to a position of intermediate distance while in lower levels of illumination is thereby assisted. Over-minusing can also help control an exo-deviation, particularly in a young patient, who can make use of their accommodative convergence.[1]

Back vertex distance (BVD)

The distance between the back vertex of the lens used to correct ametropia and the front of the cornea is known as the back vertex distance. It is particularly important to take account of this distance when prescribing for higher lens powers, ie of +/- 4.00D[4] or +/- 5.00D[8] and over. The further away a lens sits from the eye, the more positive its effective power becomes.

The importance of the vertex distance was formalised in 1956,[9] when Sir Stewart Duke-Elder chaired the committee drawing up the original recommendations to be incorporated into BS 2738. Although this standard was replaced in January 2010 by BS EN ISO 21987, the importance of recording and allowing for the BVD remains.

Each millimetre of movement in the vertex distance alters the effective power of a lens by $F^2/1000$, where F denotes the nominal power of the lens.[9] (See example in panel.)

Alternatively the following formula can be used to calculate the power of the lens needed at the new vertex distance: $F_b = F_a/(1-dF_a)$ where F_a is the power of the lens at the original position, F_b is the power needed at the second position, and d is the distance between the two positions, measured in metres. The distance d will be plus if the lens is moved towards the eye and minus if the lens is moved away.[4,8]

The BVD of a trial frame should be measured using the graticule positioned at the side of the trial frame, ensuring that the highest powered spherical lens sits in the back cell (Figure 1). If using a phoropter, a mirror system gives a side view of the eye and graticule. Consulting the manufacturer's manual will give guidance as to how to interpret what is seen. For example, the corneal aligning device, employed in the Reichert Ultramatic Rx Master Phoropter, features a long black line indicating a BVD of 13.75mm, with three additional shorter lines each

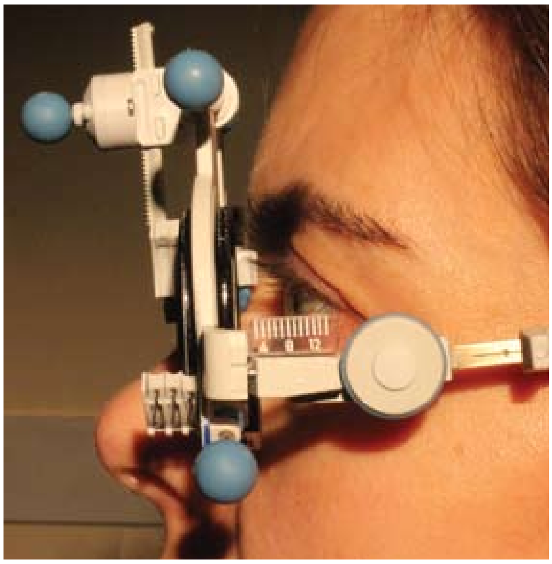
Figure 1 Assessing BVD with a trial frame

EXAMPLE

Following a sight test, where the trial frame was positioned to give a back vertex distance of 10mm, the following myopic prescription was issued:
R -12.25DS
L -13.50/-1.50 x 170

The patient subsequently chooses a new frame which, when suitably adjusted, will result in a back vertex distance of 12mm.

Using $F^2/1000$, for the RE, each millimetre of movement in the vertex distance of a -12.25DS lens will alter its effective power by 0.15D. Therefore, if the new spectacle frame will be worn 2mm further away from the eye than the trial frame was originally placed, the lens required to provide the same effective power will be -12.50DS.

Similarly, for the LE, where each meridian must be taken in turn, in the lower powered meridian, ie -13.50DS, a 2mm increase in the BVD will require an alteration in power to -13.75DS. In the higher powered meridian, ie -15.00DS, the same increase in the BVD will require an extra -0.50DS to be added to the prescription.

Therefore, the lenses to be ordered are:
R -12.50DS
L -13.75/-1.75 x 170

denoting an additional 2mm[10] (Figure 2). The BVD measured should be recorded on the record card and also on the copy of the prescription issued to the patient.

It is also worth mentioning that when considering lenses used to correct high ametropia, whether in a trial frame or phoropter, the back vertex power (BVP) of the lenses used is not necessarily their algebraic sum. Instruction manuals for phoropters describe how this issue is managed.[10] However, if using a trial frame, it is advisable to measure the BVP of the lens combination with a focimeter.[7]

Ocular examination

When examining the fundus in moderate to high myopia, it is worth remembering that with direct ophthalmoscopy, a magnified image and limited field of view will be obtained.[7] The patient can be asked to wear their spectacles, or contact lenses if they have them, or a trial lens of the appropriate power can be held up in front of the patient's eye to minimise this problem. Direct ophthalmoscopy is then carried out through the correcting lens. Alternatively, indirect ophthalmoscopy can be performed as the view of the fundus is minimally affected by ametropia when this technique is used.[7]

CORRECTION

When advising a myope on the best type of visual correction, several considerations need to be made. Individuals will undoubtedly wish to weigh up the cost involved, the convenience of different modalities, safety aspects of any proposed type of correction, as well as the effect on their cosmetic appearance.

Spectacles

These can offer a straightforward, convenient visual correction and, depending on the frame and lens choice made, costs can be kept to a minimum. Any patient who chooses contact lenses as their main form of myopia correction should be counselled on the importance of also owning a pair of functional spectacles, dispensed to a current prescription.

Frame considerations

Higher myopes should be encouraged to choose frames with a smaller eye size, requiring as little decentration of the lenses as possible.[11] The rounder the lens shape, the more even the edge thickness will be, although current trends for more angular frames make

Figure 2 BVD measurement with a phoropter

this type of selection more difficult. When considering the fit of the frame on the patient's face, it should be remembered that the smaller the BVD attained, the greater the field of view achieved.[12] If the BVD of the chosen frame differs from that of the prescription, an appropriate calculation should be performed to ensure the correct lens is ordered. (See BVD section above.)

Lens considerations

The main concern many myopes have when considering a spectacle correction is the appearance of the edge thickness of their lenses. Power rings, created by internal reflections from light coming from and near the exposed edge of a minus lens, can also create a cosmetic drawback to spectacle wear[11] (Figure 3). The appearance of these concentric rings can be reduced by ordering an anti-reflection coating, choosing dark, thickly rimmed frames or with the use of a mini-bevel.[11,12]

Figure 3 Internal reflections on a high minus lens can create a cosmetic drawback to spectacle wear

● Refractive index

The refractive index of a medium signifies how well it bends light in the yellow-green region of the spectrum.[13] It is defined as the ratio of the velocity of light in vacuum to the velocity of light in the medium.[12]

Refractive index,

$$n = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in the medium}}$$

The curvature required to produce a given surface power is inversely proportional to the refractive index of the lens material being used. The curvature decreases as the refractive index increases and consequently, the sag of the surface for a given diameter also decreases. Therefore, the higher the refractive index of the material, the thinner the lens becomes.[12]

While glass offers the highest refractive index (currently 1.90), this may be offset by the weight and safety aspects of this type of lens and patients may find that a 1.74 resin lens may provide the better all-round material.

● Reduced aperture lenses (Table 1)

For particularly high powers, this type of lens can offer a considerable reduction in weight as well as a potentially improved cosmetic appearance.

● Lenticulars

The edge thickness of this type of lens is reduced by combining the minus central aperture with a surrounding, positively powered margin. Although the aperture shape can be varied (profile, oval, round) to improve the cosmetic appearance of the lens, the fact that the eye behind the lens will appear minified through the negative portion, while the area around the eye will appear magnified through the positive outer part of the lens, means that this type of correction is not ideal.

● Myodisc

By making the margin of the lens plano, the cosmetic distractions outlined above are reduced.

● Blended lenticular

To improve the appearance of a lenticular lens, a blended design can also be considered.[12] The blending of the margin between the carrier lens and the central optic zone produces an area of poor acuity,[13] but this drawback is outweighed by several advantages. The edge or centre thickness of the lens is substantially decreased and with this, the appearance of the power ring ▶

TABLE 1

Some of the reduced aperture lenses available

Name of lens	Type of lens	Manufacturer	Material	Refractive index	Power range
Super Lenti	Blended lenticular	Norville	Resin	1.60	-15.00 to -22.00DS Cyls up to +6.00DC
			Glass	1.70	-10.00 to -19.75DS Cyls up to +6.00DC
			Glass	1.80	-20.00D to -29.75D Cyls up to +6.00DC
			Glass	1.90	-30.00 to -50.00DS Cyls up to +6.00DC
Lentilux	Blended lenticular	Rodenstock	Glass	1.70	-6.25 to -24.50 DS Cyls up to +4.00DC
Profiled lenticular	Profiled lenticular	Zeiss	Resin	1.50	60/65mm blank -14.00 to -20.00DS Cyls up to +6.00DC
			Glass	1.50	55mm blank -24.25 to -25.00DS Cyls up to +6.00DC
					60mm blank -14.00 to -24.00DS Cyls up to +6.00DC
					65 mm blank -14.00 to -20.00DS Cyls up to +6.00DC
			Glass	1.70	55mm blank -24.25 to -30.00DS Cyls up to +6.00DC
					60mm blank -20.25 to -24.00DS Cyls up to +6.00DC
					65 mm blank -14.00 to -20.00DS Cyls up to +6.00DC

reflections is reduced, along with the weight of the lens. Additionally, the appearance of the spectacle wearer's temples and cheeks, through the edge of the lenses, is relatively unchanged.[11]

● Anti-reflection coating

Dispensing an anti-reflection coating will help reduce the appearance of power rings in full aperture negative lenses, as previously indicated, and also improve the cosmetic appearance of reduced aperture lenses.

● Lens form

Dispensing lenses with best-form curvatures will ensure that off-axis errors are minimised.[12] However, myopes may well have become accustomed to wearing flat form lenses, as these are often chosen due to the fact that this type of lens form will always be thinner and lighter for any given power than meniscus form.[13] It is recognised that myopes often find it difficult to adapt to a change in lens form, despite the better visual performance an alternative may offer. Caution should therefore be exercised in this matter during the dispensing process.

Contact lenses

Contact lenses offer a way of correcting myopia without the need to wear spectacle frames and lenses which for some individuals can be cumbersome, impractical or cosmetically unacceptable.

Myopes who change their form of visual correction from spectacles to contact lenses benefit from an increased retinal image size.[1,14] This can have the advantageous effect of increasing visual acuity for very high myopes. However, it would be prudent to warn patients that this change in retinal image size may affect their distance judgement and cause some disorientation, particularly when adapting to the new form of correction.[14] The minification effect that negative-powered spectacle lenses have on the myope's eye are eliminated when contact lenses are worn.[14] Contact lens wear also means that the dynamic field of view is not limited by the spectacle frame or lens edges.[1] Additionally, correction of anisometropic prescriptions with contact lenses can help minimise the aniseikonia that this type of prescription creates when dispensed in spectacle form.[1]

As the BVD of a contact lens is effectively zero, when using a spectacle prescription to help select a first choice contact lens, a BVD calculation should be carried out to ensure that an appropriately powered lens is chosen.

Myopes require more accommodation when wearing contact lenses than spectacles.[1,5,14] For a patient approaching presbyopia, the extra accommodation needed for near work when contact lenses are worn may mean that a near vision prescription is necessary at an earlier stage than when spectacles are used. Further close work difficulties may be encountered by contact lens wearing myopes as the base-in effect utilised by converging for near work and looking through the nasal part of their spectacle lenses is lost.

The use of contact lenses to correct myopia does not necessarily overcome the edge thickness difficulties created by negatively powered lenses. If soft lenses are fitted, the resulting reduction in oxygen transmission at the limbus can result in an increased risk of neovascularisation. The thicker edge of a high powered minus rigid gas-permeable lens can cause the lens to be hitched up under the upper lid, resulting in an upwards displacement of the lens.[14]

Surgery

For some myopes, the desire to find a permanent correction for their refractive error leads them to consider surgery and an estimated number of around 120,000 procedures were carried out in 2009.[15] Photorefractive keratometry (PRK) was the most commonly performed procedure until the introduction of laser-assisted *in situ* keratomileusis (Lasik) in the mid 1990s.[16] It has been shown that PRK and Lasik have a similar long-term ▶

visual acuity efficacy in the treatment of eyes with high myopia,[17] but a significant risk of corneal haze exists when PRK is used.[16-18]

Currently, the most common types of laser eye treatment carried out in the UK are Lasik and laser epithelial keratomileusis (Lasek).[15] In Lasik, a microkeratome is generally used to generate a hinged corneal flap of approximately 80-200µm[18] which, by the nature of its thickness, involves stromal tissue. Lasek was developed in the late 1990s,[19] combining aspects of PRK and Lasik, to avoid the flap related complications of Lasik and the slow recovery and risk of corneal haze associated with PRK.[20] In Lasek, alcohol assisted epithelial removal takes place, producing a thinner flap. The creation of a thinner flap leaves the stroma intact. This has the potential advantage of safely treating a myopic eye with a thinner cornea[21] or higher refractive error,[20] as well as making any postoperative infections easier to manage.[22] However, visual recovery appears slower after Lasek compared to Lasik when used to correct low,[23] moderate[24] and high[25] myopia.

Evidence indicates that there has been an increase in the number of refractive surgery clinics that now offer Epi-Lasik, wavefront technology (which can help reduce higher-order aberrations reported to be created with the Lasik procedure)[26-27] and those which have invested in femtosecond surgery (Figure 4) (which uses a laser to create the corneal flap, rather than the traditional mechanical blade). However, a reduction in the number of clinics that offer phakic intraocular lenses and Intacs (corneal implants) has also been documented.[15]

It has been reported that patients who are male, older and have high myopia preoperatively, may be at increased risk of retinal detachment following Lasik[28] and it is recommended that a rigorous dilated fundus examination, incorporating sclera indentation, is carried out on any patient considering refractive surgery. It is recommended that any retinal lesions predisposing them to the development of retinal detachment are treated prior to refractive surgery.[29]

It is also important to remember that a reduction in corneal thickness, such as that encountered in refractive surgery patients, will result in an underestimation of any intraocular pressure measurement taken.[7,30] As mentioned in Part 2 of this series, myopia is associated with an increased incidence of primary open-angle glacoma (POAG). Care should therefore be taken to ensure that this effect on the intraocular pressure is not overlooked when considering referral criteria for suspect glaucoma patients.

Figure 4 Femtosecond surgery uses a laser to create the corneal flap

Orthokeratology

This is defined as the 'reduction, modification or elimination of myopia by the programmed application of contact lenses'.[31] Orthokeratology is the term often used to indicate the contemporary process of accelerated orthokeratology, whereby a reverse geometry rigid gas-permeable lens is fitted for overnight wear.[32] The patient can then benefit from clear, uncorrected vision during the day.[33] This is a minimally invasive, reversible procedure that appears to offer a safe alternative to spectacle, contact lens or surgical correction of moderate myopia, typically of the magnitude -0.75 to -4.00D.[32]

Conclusion

This article aims to give a basic *aide-memoire* of the factors to take into account when refracting and prescribing for myopic patients, along with a summary of the various options available to correct their refractive errors. While some patients will have a very clear idea of how they wish to proceed, others may appreciate a rundown of the choices available. Accurate refraction and examination techniques, combined with an awareness of current myopia solutions will ensure that all myopic patients receive their most appropriate visual solution.

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● **Catherine Viner** is senior lecturer, Bradford School of Optometry and Vision Science, University of Bradford, UK

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1 If a lens of -12.25DS measured at 10mm is set 2mm further from the eye, what should the new power be to provide equivalent refraction?
A -12.25DS
B -12.50DS
C -12.75DS
D +12.25DS

2 Which of the following is true regarding ophthalmoscopy of a high myope?
A Direct ophthalmoscopy is the preferred technique
B Indirect ophthalmoscopy will result in a narrower field of view
C Ophthalmoscopy is not influenced by ametropia
D Fitting a high myope with a corrective contact lens will increase the field of view when viewing with direct ophthalmoscopy

3 What is the highest available refractive index of a spectacle lens?
A 1.70
B 1.74
C 1.90
D 2.10

4 Which of the following regarding near vision in myopes is true?
A A myope will require more accommodation when wearing contact lenses compared with spectacles
B A myope will require extra convergence with a spectacle lens
C An esophoric myope will be less stable without distance spectacle correction for near work
D Vertical prismatic difference will be exaggerated with contact lenses

5 What impact will corneal refractive surgery have upon intraocular pressure?
A None
B Increase
C Decrease
D Apparent decrease in tonometry measurement

6 Orthokeratology is best defined as which of the following?
A The permanent distortion of cornea to reduce refractive error
B The programmed application of lenses to permanently reduce ametropia
C The programmed application of lenses to redistribute corneal tissue providing temporary reduction of refractive error
D The reduction of corneal substance by photoablation

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