Maximising Lens Appearance

DISPENSE WITH CONFIDENCE PART 1 C-19373 O/D

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Dispensing spectacles is something of an art, which requires a myriad of skills to ensure that every patient and spectacle-wearer walks away from your practice with confidence that they have the best possible spectacles for them, not only in terms of the optical performance but also the cosmetic appearance. Anyone involved with dispensing spectacles must have the ability to assist the patient in choosing a suitable frame design relative to the refractive prescription. It is this second requirement which will use a dispenser's knowledge for maximising lens appearance in the finished spectacles. This article offers guidance as to how this can be achieved.

Considerations

In order to ensure the best spectacle lens appearance, the following need to be considered throughout the dispensing process – the lens form, the refractive index of the lens, the minimum substance of uncut lens, the diameter and shape of the lens, and the need for an anti-reflection coating.[1] The rest of this article describes each of these in turn, so that practitioners can feel more confident about maximising lens appearance.

Lens form

The form of the lens describes both its shape and thickness. As aspheric lenses will be the subject of the next article in this series they will not be covered in detail here. However, one should be aware that utilising aspheric lenses will give resultant thinner and lighter lenses than spherical counterparts. From a practical point of view, using different lens forms means that lenses which have the same focal length can look quite diverse. Although there are effectively an infinite number of lens forms, they fall into two basic categories: flat and curved, as depicted in Figure 1. For spherical lenses, the equi-concave form is the thinnest and lightest form so that as the lens is bent into a curved form, both the edge thickness and weight increase.[2] This is dictated by the sag formula (Figure 2). The weight of each lens is found by multiplying the lens volume by the density of the material being dispensed. The volume of each lens can be calculated using Figure 3. Sag formulae have a very practical use, whether you are applying the exact or the approximate formula. With regard to spherical lenses, if you need to calculate the maximum thickness of a lens for a patient, this can be done in practice providing you know or can establish all of the required parameters ie lens thickness and diameter, lens radius/base curve, refractive index, and power. The various relationships are also shown in Figure 1.[3]

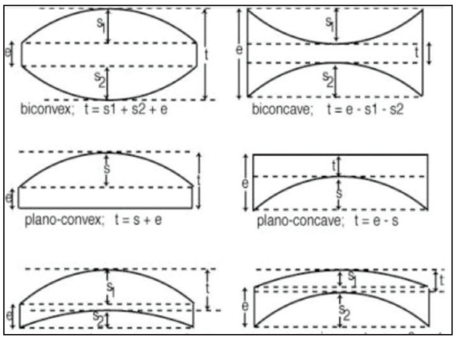

Figure 1
Positive (left) and negative (right) lens forms. Meniscus lenses are also known as curved while all others are flat forms; t = centre thickness; e = edge thickness; s1 = sag of the front surface; s2 = sag of the back surface. Reproduced with permission from Walsh[3]

Best form lenses should meet the following criteria in order to produce a point image on the retina – 1. They need to totally negate any oblique astigmatism, 2. They need to ensure the point image falls on the far point sphere (FPS) (and so the FPS and Petzval surface coincide). In practice, these criteria cannot actually be met and as such the three possible lens compromises are:

- Point focal lens – oblique astigmatism is eliminated, so a point image is produced. Field curvature is still present so the point image is not on the FPS. Cosmetically, these lenses give the steepest resultant lens curves and are of increased thickness
- Percival lens – some oblique astigmatism remains so a point image is not formed. Field curvature is eliminated so the image can be made to coincide with the FPS. Comparatively, these lenses are aesthetically better than the point focal lenses as they are flatter
- Minimum tangential error lens – some oblique astigmatism remains so a point image

Exact: Sag, $s = r - \sqrt{(r^2 - y^2)}$ where: r = radius of surface, $2y$ = diameter of lens, F = power, n = refractive index

Approximate: Sag, $s = (y^2 \times F) / 2000(n - 1)$

Figure 2
The exact sag and approximate sag formulae

is not formed. Field curvature is corrected in the tangential (T) meridian only (and so remains in the sagittal (S) meridian) and so the T image shell coincides with the FPS. These lenses behave like Percival form lenses when fitted closer to eye and like point focal lenses when fitted further from the eye.

If lenticular lenses (Figure 4) are dispensed, lens appearance can be improved for very high prescriptions (±10.00D). Their main purpose is to reduce the thickness and weight of high powered lenses. Standard lenticulars (comprising a prescription aperture and a plano or lower powered margin) are used to a lesser extent today as now blended lenticulars and polynomial aspheric lenses tend to be dispensed more commonly. Dispensing disadvantages of standard lenticulars include having poor cosmetic appearance, increased spectacle magnification, reduced field of view and a ring scotoma (which can induce 'jack-in-the-box' effects whereby an object suddenly appears from outside the scotoma area upon movement) when viewing through the lens margin. Blended lenticulars have the optical zone blended with the margin and therefore, although this gives an aperture

$$\text{Volume (V)} = [\pi s^2 (3r - s)] \times {}^1/_3$$

Figure 3
Calculation of the volume of a lens; s = sag; r = radius of curvature of the surface

that is even more reduced than in standard lenticulars, there is a better cosmetic outcome.[3]

Refractive index

The higher the refractive index of a lens, the thinner the lens will be and so the better its final appearance. The primary reason for this is that lenses manufactured from higher index materials will have lower sag and therefore will appear flatter ie it will look like a lens of lower power. This does not have any bearing on the weight of the lens. Using curve variation factor (CVF), it is possible to calculate how much thinner a high index lens will be in comparison to a lens manufactured from standard CR39 (plastic) or Crown (glass) materials of the same power. CVF is a ratio which describes the variation in surface power of an optical medium when compared with a standard reference index (1.498 for plastic and 1.523 for Crown glass). Table 1 summarises the typical CVF figures for various indices of plastic and glass materials. The weight of a lens is dependent on its density. The density of a lens is measured in mass per unit volume. Specific gravity is often quoted and is equal to the density of a material relative to the density of water (which is 1g/cm^3). However,

Plastic lenses	**Curve Variation Factor (CVF) Relative to CR39 CVF = (1.498-1)/(n-1)**	**Reduction in lens edge thickness**
1.586	0.85	15%
1.600	0.83	17%
1.740	0.67	33%
Glass lenses	**Curve Variation Factor (CVF) Relative to Crown CVF = (1.523-1)/(n-1)**	**Reduction in lens edge thickness**
1.7	0.75	25%
1.8	0.65	35%
1.9	0.55	45%

Table 1
Curve variation factors (CVF) for high index lenses, indicating change in edge thickness compared with a standard reference. "n" is the refractive index of the high index lens in question

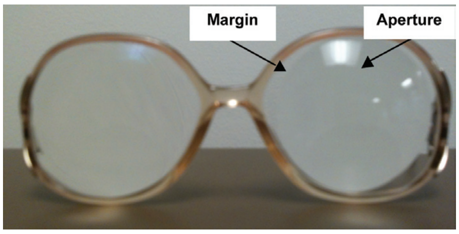

Figure 4
Lenticular lenses. The prescription of these lenses is +14.00/-2.00x100. The lens on the left is a blended lenticular lens while the lens on the right is a standard lenticular lens with its obvious aperture and margin

a material having a low density does not necessarily mean it is going to produce a lighter lens. This is because the amount of material and form of lens used must be taken into account too ie a higher refractive prescription produced in a point focal form (and therefore having the greatest thickness) will result in more lens material being present compared with if the refractive prescription were lower and/or a Percival lens form were used.

Minimum substance of uncut

Up until now, comparisons have only been made between positive lenses of similar edge thickness and negative powered lenses of the same centre thickness, but practically this is unlikely to be the case. Considering negative powered lenses, it is conventional to have a minimum centre thickness of approximately 2mm in CR39 to 0.8mm in certain glass materials. The centre thickness naturally affects the edge thickness of the finished lens. It is no good having a lens material of high refractive index if the minimum lens thickness has to be considerably thicker than Crown or CR39 for mechanical stability. Therefore, the manufacture of high index lenses with the minimum possible centre substance is one of the main aims of lens producers.[4] In the case of positive lenses, the controlling factor for the minimum possible centre thickness is the minimum acceptable value at the farthest point from the optical centre in the edged lens. In order to obtain this minimum value, accurate calculation of the uncut diameter of the lens before surfacing is required (Figure 5), otherwise overly heavy finished lenses with unacceptably thick edges will be produced.

Minimum size uncut (mm) = Finished Lens Size + (2 x Resultant Decentration) + Wastage for Glazing

OR in other words:

Minimum size uncut (mm) = (Difference between Patient's PD and Frame PD) + Longest Lens Diameter + 2mm

Figure 5
Calculation of the minimum size uncut of a lens (see text for details);[5] PD = pupil distance

Diameter and shape of lens

A frame should be chosen where the boxed centre distance and the patient's PD are virtually equal in order to ensure correct centration of the lenses and minimise the decentration required. This positions the paraxial zone of the lens prescription most effectively, as far as the visual field is concerned. It also reduces problems which may arise from unwanted differential prismatic effects and ghost images. It also allows the smallest possible blank size to be established as any decentration will increase the size of the blank required.[5] Round or oval shaped lenses tend to be a better shape of lens to choose for hyperopic patients, as this will provide a more even edge thickness in all meridians of the lens. Other shapes will require a larger blank size and so a thicker and less cosmetically appealing lens will result. Rectangular shaped lenses are better for myopic prescriptions eg with cylinder axes at 180°, as the highest power meridian is vertical. Equally, aviator shaped lenses should be avoided for those with oblique cylinders, as the thickest part of the lenses will occur in the nasal "cut-out" portion, making the final spectacles look poor.

Multi anti-reflection (MAR) coating

Dispersion is the amount by which a lens material spreads the different wavelengths of light passing through it. The Abbé number, otherwise known as constringence or V-value, is its reciprocal. A reduction in V-value is accompanied by an increase in unwanted chromatic aberration. When looking off-axis, the patient will experience colour fringing when a lens material has a low Abbé number (Table 2). When the patient looks through a point away from the optical centre, prismatic effect is induced. This causes dispersion of light due to transverse chromatic aberration (TCA) which in turn gives rise to tangential blur. This can be calculated for a lens from: TCA = P/V = cF/V where P is the amount of prism, V is the Abbé number, c is the amount of decentration (the viewing point from the optical centre) and F is the power of the lens. This will be experienced by the patient as blur when contrast is low and coloured fringes when contrast is high. The amount of light that is reflected from the surface of a lens needs to be considered when dispensing spectacle lenses. Some small loss from CR39 and Crown glass does not cause too many problems. However, ghost images are seen when spectacles are used for night driving. High index lens materials have far increased levels of light loss compared with CR39. Unacceptable levels of loss are considered to occur if there is reflectance of over 12% of input light. This can commonly occur with high index lens materials and as a result, an anti-reflection coating is always recommended when dispensing a material of index 1.6 or above.[4] Reflections of concern to the patient are firstly forward reflections (from the front and back surfaces of the lens), which are experienced as veiling glare that makes the lenses more visible and the eyes less so. Total internal reflections will be seen from the front, especially in higher powered myopic prescriptions, in the form of power rings due to reflections at the bevel edge of the lens. Reflections also take place from the lens surfaces towards the patient's eyes, especially if bright light is behind the patient. All of these types of reflections can be markedly reduced by using anti-reflection coatings, which also improve considerably the way the spectacle lenses look (Figure 6).[5]

Case scenario 1

High myope eg -12.00/-1.00x90 R+L

As far as lens form is concerned, the available lenses can be divided into full aperture lenses and reduced aperture lenses. The patient is likely to be concerned by the edge thickness of the finished lens. If the lens incorporates inward horizontal decentration, it will be the temporal edge that displays the greatest edge thickness. When dispensing full aperture lenses for high myopia, the use of higher refractive index aspheric materials combined with an anti-reflection coating will provide the best lens of choice. Such lenses give a reasonable degree of control over the edge substance while providing good off-axis performance in oblique gaze whilst serving to minimise the effects of TCA. The following points are important when dispensing such patients:

- Use materials with as high refractive indices and Abbé numbers as possible
- Ensure correct horizontal and vertical centration with pantoscopic tilt
- Use best form designs

Lens material	Abbé Number
Crown Glass	58
CR39	58
Trivex	43
1.6 Plastic	36
1.7 Glass	36
Polycarbonate	30

Table 2
Optical quality of various lens materials in terms of constringence (Abbé number). See text for details.

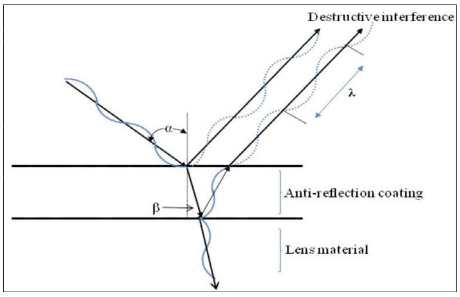

Figure 6

Diagram showing how destructive interference is utilised in the construction of an anti-reflection coating; α = angle of incidence, β = angle of refraction and λ = wavelength

- Be sensible with frame selection – consider shape and size carefully
- Fit the spectacle frame with as small a vertex distance as possible

With glass lenses the refractive index increases with density (mass/volume). If weight is the patient's priority then a plastic lens has to be the material of choice. It is, of course, important to dispense the lens material best suited to the patient's requirements. For this patient, providing monetary constraints permit, 1.74 aspheric hard and MAR-coated lenses would be a good option.

Case scenario 2

High hyperope eg +12.00/-1.00x90 R+L

Nasal edge thickness, centre thickness and overall weight will be the areas of most concern to the patient. The following points are important when dispensing patients with high positive powered lenses:

- Use plastic materials with as high refractive indices and Abbé numbers as possible
- Use a small a blank size as possible
- Ensure correct horizontal and vertical centration with pantoscopic tilt
- Consider best form designs
- Be sensible with frame selection – consider shape and size carefully

Unlike high minus lenses, the finished blank size of a high powered plus lens plays a vital role in dictating the thickness of the lens when glazed. The avoidance of unwanted decentration is essential and combined with minimum substance uncut along with higher refractive index materials and aspheric surfaces, optimum results can be obtained. Only plastic materials should be considered for high hyperopes due to the volume of material involved, as glass lenses would prove very heavy and unsafe. If considering lenticular lenses there is the option of using standard lenticulars, blended lenticulars or polynomial aspheric lenticular lenses. Polynomial lenses give the main advantage of an absence of a ring scotoma and Jack-in-the-box effects. Polynomial lens designs combine the advantages of both lenticular and full-aperture lenses in that there is no visible dividing line, good mean oblique power when viewing off-axis, reduced distortion, slightly thinner and give an increased field of view. For this patient, providing monetary constraints permit, 1.67 aspheric hard and MAR coated lenses would be a good option.

Conclusion

When dispensing spectacles, there are various criteria which need to be taken into account when considering how to maximise lens appearance. These criteria are lens form, refractive index, minimum substance uncut, lens shape and MAR coating. This article has described the key considerations and has provided examples of how to apply these considerations to real dispensing.

About the author

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References

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1. Which of the following is NOT a type of best form lens?
a) Point focal lenses
b) Polynomial lenses
c) Percival lenses
d) Minimal tangential error lenses

2. What is the reduction in edge thickness of a 1.67 high index plastic lens when compared to CR39?
a) 15%
b) 17%
c) 26%
d) 33%

3. Which of the following is the exact sag formula?
a) $s = r + \sqrt{(r^2-y^2)}$
b) $s = r^2 - \sqrt{(r^2-y^2)}$
c) $s = r - \sqrt{(r^2-y)}$
d) $s = r - \sqrt{(r^2-y^2)}$

4. Which of the following is NOT a disadvantage of standard lenticular lenses?
a) Reduced field of view
b) Poor cosmetic appearance
c) Decreased spectacle magnification
d) Ring scotoma

5. Which of the following is NOT a characteristic of polycarbonate lens materials?
a) Curve variation factor of 0.65
b) Colour fringing with off axis gaze
c) Refractive index of 1.586
d) Abbé number of 30

6. Which of the following is NOT a benefit of an anti-reflection coating?
a) Reduction of veiling glare
b) Cutting down of power rings
c) Improvement in cosmetic appearance
d) Increased visual acuity