A question of colour

In the latest of her series on calculations in practice, **Janet Carlton** considers chromatic aberration

Lens designers are often concerned with aberrations and how to remove them from spectacle lenses. But many patients are either unaware of any peripheral view compromise, or assume that what they see is 'normal'.

As long as the eye is viewing along the optical axis of a spectacle lens, it will perform perfectly and provide a point image of a point object. But as the eye moves away from the centre of the lens to gaze through the periphery, the aberrations in the lens will cause the image to deteriorate. The aberration most likely to be noticed by the patient is transverse chromatic aberration (TCA).

This is seen as coloured fringing around areas of stark contrast when viewing through the periphery of the lens. Most patients do not notice or complain about this fringing, but once they become aware of it – usually prompted by a practitioner asking, 'Do you see any coloured fringing?' – it will be impossible to ignore. This is the one aberration where the only 'cure' is to change lens material.

Three factors influence the amount of TCA:

- The viewing distance from the optical centre of the lens
- The power of the lens
- The V value of the material.

The greater the angle of gaze, the higher the power and the lower the V value, then the poorer the image quality will be.

TCA is more of a problem for higher powered lenses, especially those of a higher-index lens of lower V value. These aberrations are caused by dispersion within the lens material, and are due to the fact that each colour of light has a different wavelength – blue light focusing first and red having the longest focal length (Figure 1).

The V value of the lens is related to the difference between the focal lengths of the different colours.

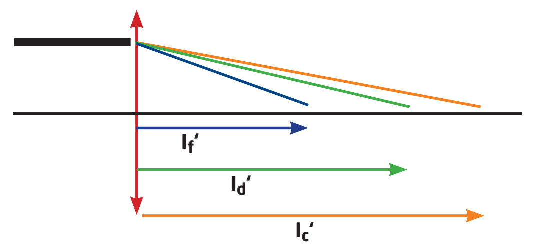

Figure 1

Wavelengths	Designation
587.6nm	d
656.3nm	c
486.1nm	f

$$\text{Dispersive power} = \frac{(n_f - n_c)}{(n_d - 1)} = \frac{\text{Mean dispersion}}{\text{Refractivity}}$$

Constringence or V value = 1/Dispersive power

Constringence varies from material to material, and falls roughly between 25 and 70. Water has a V value of 55 and both crown glass and CR39 (allyldiglycol carbonate material, CR39 is actually a trade name) have values of 58. Table 1 shows some of the currently available materials and their index and V values.

Figure 2 shows a schematic representation of TCA as

TABLE 1
Available materials

Material	Index	V value
Glass		
15 white	1.523	59
16 white	1.600	42
17 white	1.700	42
18 white	1.802	35
19 white	1.885	31
Resin		
CR 39	1.498	59
PPG Trivex	1.532	46
Spectralite (Sola)	1.537	47
PPG HIP	1.560	38
Polycarbonate	1.586	30
Nikon	1.740	32

TABLE 2
TCA when viewing 10mm from the optical centre of the lens

Power	V value	cF/V	= CA	Problem?
5DS	58	1 x 5/58	=0.086	**No** low-powered lens and high V value, CA <0.01
5DS	40	1 x 5/40	=0.125	**Yes** low-powered lens and low V value, CA >0.01
15DS	40	1 x 15/40	=0.375	**Yes** high-powered lens and low V value, CA >0.01
10DS	58	1 x 10/58	=0.17	**Yes** high-powered lens and low V value, CA >0.01
1DS	58	1 x 1/58	=0.017	**No** low-powered lens and high V value, CA <0.01
10DS	40	1 x 10/40	=0.25	**Yes** high-powered lens and high V value, CA >0.01

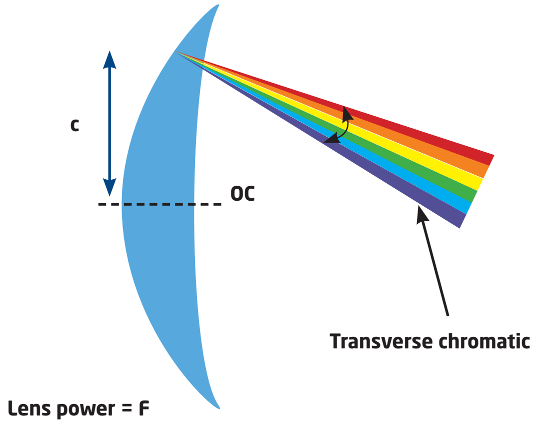

Figure 2

seen when the wearer views through a peripheral lens area.

From Figure 2, we can calculate TCA as follows:

$$TCA = \frac{c \times F}{V} \text{ (c in centimetres)} \quad \text{Or } TCA = \frac{P}{V}$$

Where P = prism

Any material with a calculated TCA value over 0.01, has the potential to cause problems (Table 2).

As chromatic aberration is a product of the material and the direction of gaze, advising a patient troubled by TCA to use the central part of the lens only, will reduce any coloured fringing. This is not a particularly efficient way of solving your patient's problems. You may have dispensed a fused glass bifocals, where the segment is made of a material with a lower V value. The patient will be looking through the area with the greater potential for CA for reading. Black print on a white background is just the type of image to exhibit CA.

A better solution is to change the material to one with a higher constringence. There are disadvantages in doing this as well, as the higher index lens (lower V value) will have been dispensed for a reason. If you have dispensed the lens to achieve a thinner lens, you will need to return to a thicker lens (many patients will put up with aberrations for a thinner lens, some may not). You may have dispensed a polycarbonate lens (V=30) to glaze into a rimless frame; your only options now, are to dispense a Trivex lens (equally safe and with a V value of 46) or change to a supra or full frame.

These are the only solutions for a patient complaining of chromatic aberrations. Anti-reflection coatings will not remove TCA, it is a property of the lens material not the surface.

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