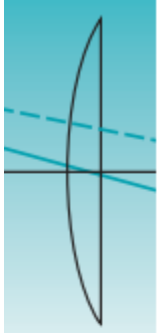
# 11 ANISOMETROPIA AND ANISEIKONIA

Binocular vision can be disturbed by large differences in the refractive error between the two eyes: *anisometropia*. When this is left uncorrected, central suppression areas can develop in the eye with the more blurred vision. Anisometropia over 1.50 D results in a significant increase in the risk of amblyopia and decrease of binocular function (Weakley 2001) and higher anisometropia is likely to be associated with worse amblyopia and stereoacuity (Rutstein & Corliss 1999). Poorer stereoacuity is associated with reduced performance at motor tasks (Hrisos et al 2006) and at driving (Gresset & Meyer 1994, Bauer et al 2000).

If anisometropia occurs in young patients, and particularly before the age of 6 years when the visual system is still not firmly established, amblyopia may also be present. Often in these cases the vision is very good in one eye, so that the anisometropia and reduced vision in the other eye is not discovered. The older the child the more difficult it is to treat the amblyopia and restore full acuity. The importance of early eye examination is obvious and the procedures for the examination of young children are dealt with in Chapter 3. There is no doubt that many cases of anisometropic amblyopia are preventable by early examination and correction by spectacles. The treatment of anisometropic amblyopia is covered in Chapter 13, together with other types of functional amblyopia.

With patients of any age, the prescribing of glasses to correct anisometropia may present two other problems:

(1) *Prismatic effects:* when the patient is not looking through the optical centres of the lenses, a difference in prismatic effect between the two lenses can make binocular vision difficult or impossible. These prismatic effects present more difficulties when the patient looks above or below the centres, as the vertical tolerance to prisms is very much less than the horizontal. For some patients, a vertical prismatic effect of 0.5 Δ can impair stereopsis.
(2) *Aniseikonia:* when the lenses are of different powers, there will be a larger retinal image in one eye than the other because of the difference in spectacle magnification.



These two problems are discussed in more detail below. In both cases, these difficulties will cause more problems in older patients, with previously uncorrected patients or where a large change in prescription is given.

## Prismatic effects

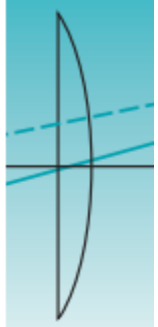
### *Diagnosis*

The main factor in recognizing a difficulty due to prismatic effects is the presence of the anisometropia itself. It may also be found that older children and teenage patients with anisometropia have spasm of accommodation, and where this is suspected a cycloplegic refraction should be carried out. The symptoms of the anisometropia will be those due to the type of refractive error in the better eye: asthenopia for near vision in hypermetropia and blurred distance vision in myopia. Some patients may be hypermetropic in one eye and myopic in the other. In these cases, they may use one eye for distance vision and the other for close work. If there is no significant refractive error in one eye, the patient may have no symptoms. This may also be true in cases where no glasses have been worn and suppression has developed.

Many patients will experience no problems when spectacles are prescribed; the younger the patient when glasses are first worn the more likely it is that trouble can be avoided. This is probably because patients with stable binocular vision or compensated heterophoria can usually adapt to prismatic effects in a very short time (Carter 1963). The symptoms that occur when the patient does not adapt to the correction for anisometropia consist of difficulties in getting used to the new glasses: typically headache or intermittent diplopia. Troubles seldom occur when the anisometropia is less than 2 D. If spectacles that fully correct the anisometropia can be tolerated in childhood then the prognosis for successful spectacle wear in adult (pre-presbyopic) life is good, since anisometropia usually gradually reduces over the years (Ohlsson et al 2002b).

### *Investigation and evaluation*

Often, these difficulties can be avoided by anticipation. A partial correction is given in the more hypermetropic eye in those cases where there has been no previous correction or where there is a large difference between the previous correction and the new one. The extent of this modification to the prescription can be determined by the Mallett fixation disparity test or the infinity balance 'nodding test' (Ch. 9). The patient looks at the fixation disparity vertical target through the full correction and is asked to move the head vertically up and down in a nodding movement so that the eyes look through the lenses above and then below the optical centres. If a vertical fixation disparity is induced then the prescription is modified until this does not occur. An alternative method is to carry out the cover test



with the eyes looking through the near visual points and again when looking through the optical centres. The power of the more positive lens is reduced until a good recovery movement to the induced hyperphoria occurs.

As a rough guide, the prescription for the more hypermetropic eye is reduced by one-third of the change in the anisometropia (the difference between the two eyes) compared with the previous prescription. This will mean that it is reduced by one-third of the anisometropia in the case of a patient who has worn no previous glasses. However, it must not be assumed that all patients with anisometropia will experience difficulties with their new glasses. Some patients with marked anisometropia will settle very readily to a new prescription, whereas others with low degrees will experience symptoms.

Patients often learn very quickly to turn the head rather than the eyes, so that they always look through the optical centres of the lenses. It sometimes helps to encourage patients to do this. If the patient needs bifocals then round top segments of different sizes in each lens can be used to control the vertical prismatic power in the reading portion. A more detailed coverage of this subject can be found in Rabbetts (2000). Optically, the best approach is to fit contact lenses, which move with the eyes so that no prismatic effect is induced and which also reduce aniseikonia (Evans 2006a). Refractive surgery has been advocated for similar reasons (Paysse et al 2006).

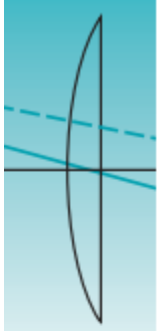
## Aniseikonia due to spectacle magnification differences

Most aniseikonia arises from the difference in spectacle magnification that accompanies anisometropic corrections; this type may be called *acquired optical aniseikonia*. Other types will be considered separately later in this chapter. Interestingly, everyone experiences aniseikonia in asymmetrical convergence of the eyes, for example when converging to an object in our peripheral vision which will be closer to one eye than the other, and this may become of the order of 5–10% or more. This *physiological aniseikonia* appears to be automatically compensated and gives rise to no symptoms (Romano 1999).

### *Investigation*

The possibility of an aniseikonic problem occurring can be foreseen largely from the presence of the anisometropia, particularly when there is a difference in spectacle magnification of more than 2% (some authors say 5%). This means that anisometropia of as little as 1.25 D may cause clinically significant aniseikonia, although the precise value will depend on the prescription, the back vertex distance and the relative ocular dimensions (Rabbetts 2000). Typically, 1 D of anisometropia causes between 1% and 1.5% of aniseikonia (Borish 1975, p 272).

There is a large variation between people in the amount of aniseikonia that they can tolerate (Romano 1999). Again, symptoms will consist of the



non-tolerance of the new glasses, and sometimes headache and intermittent diplopia. A symptom more characteristic of aniseikonia is a disturbance in spatial perception: the floor appears to slope or other horizontal objects appear tilted when looking through the new glasses. Induced aniseikonia (using size lenses) of 3–5% causes a reduction in stereoacuity (Jimenez et al 2002) and of 5% or more significantly reduces binocular contrast sensitivity and binocular summation (Jimenez et al 2004a).

Aniseikonia can be investigated with an eikonometer (Morrison 1993), although this apparatus is very rare. There are two types of eikonometer:

(1) *Ames eikonometer*, which presents a separate image to each eye so that the patient can make a direct comparison of the image sizes; polarizing filters can be used (Romano 1999)
(2) *Space eikonometer*, which allows the patient to recognize distortions of space perception, such as a tilting of the frontoparallel plane out of its normally perceived position.

In both cases, measurement of image size differences are made by incorporating an afocal optical system of variable magnification, which is adjusted until a normal appearance is reported by the patient. Neither of these instruments gives very consistent results. A number of readings is taken and, if the spread of readings is less than the mean value, this mean value may be taken as the size difference. Its use may be more necessary in types of aniseikonia other than acquired optical.

Since most eyecare practitioners do not have an eikonometer, precise quantification of aniseikonia is not possible in routine practice. However, it is possible to obtain a diagnosis and qualitative estimate of aniseikonia using commonly available refracting equipment that dissociates the right eye from the left eye images. For example, many projector charts have a muscle balance test comprising a pair of 'square brackets' one of which is seen by the right and the other by the left eye. Patients can directly compare the size of these to give an estimate of aniseikonia. A similar technique can be used with letter charts having cross-polarized letters or cross-cylinder targets. A more accurate measure can be obtained if a tangent screen is available. The two eyes are dissociated with a vertical prism that is too great to be fused (e.g. 8 Δ) and the position of numbers on the smaller image of the tangent scale is compared to the position of the same numbers on the larger to calculate the magnification difference. This approach can be improvised using a line of Snellen letters for distance vision or a centimetre rule for near vision.

## Management

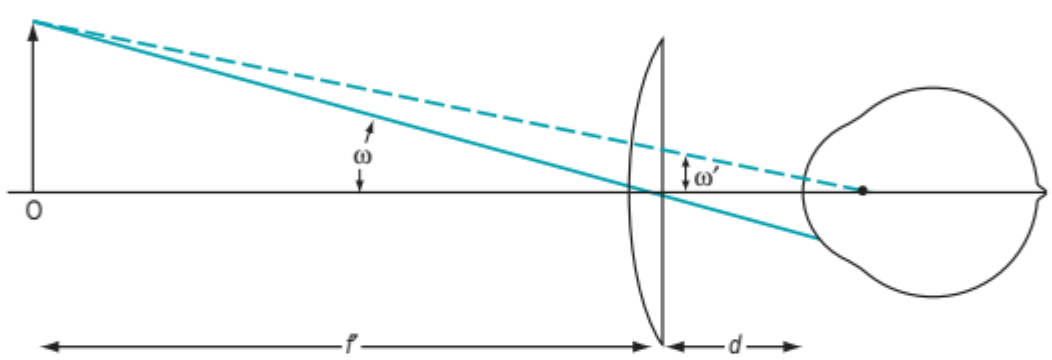
Anticipation of the difficulties is again very important. The following should be considered:

(1) Warn the patient that difficulties in space perception may occur during the first few days of wearing the new glasses. It is usually adequate

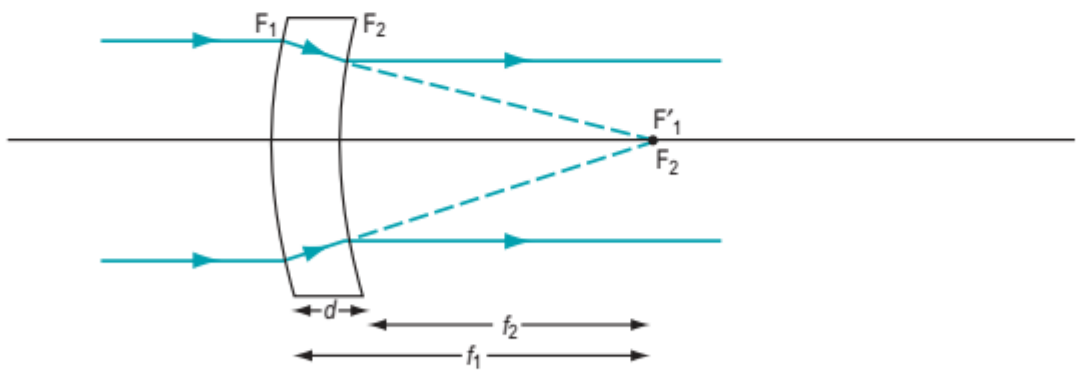
to say that the patient's particular prescription is of the type that may require a few days to settle to the new glasses. In most cases, these problems will disappear after a short time, particularly if some of the factors mentioned below have been considered. Warn patients not to drive or operate machinery until they have adapted. Some strabismic patients may be less able to tolerate optically induced aniseikonia than patients with normal binocular vision (Bucci et al 1999), so they may be less able to tolerate large refractive changes.

**(2)** Reduce the difference in spectacle magnification by considering the factors that contribute to it (Fig. 11.1):

**(a)** *Lens power:* the higher the power, the higher the spectacle magnification. A partial correction for one eye can be considered, again on the basis of reducing by about one-third of the change in the

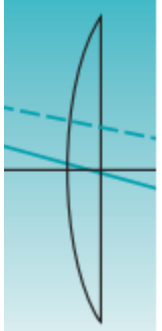



A




B

**Figure 11.1** (A) The spectacle magnification (SM) is the ratio of the angle subtended at the eye by the object to the angle subtended at the spectacle lens. This can be shown to be SM = $1/(1 - dF)$, where $d$ is the back vertex distance, and $F$ the power of the lens. As the lens is moved closer to the eye ($d$ decreases), spectacle magnification will become unity. As the power of the lens ($F$) increases, the spectacle magnification will increase. (B) The magnification of a 'thick' lens is the ratio between the focal lengths of the surface powers. This can be shown to be $1/(1 + tF')$, where $F'$ is the power of the front surface and $t$ is the reduced thickness of the lens ($d/n$).



anisometropia. In some cases, a partial correction in both eyes may be appropriate, as this will leave the patient to exert the same accommodative effort in both eyes. With young patients, such a binocular reduction will give sufficient correction to relieve any symptoms of hypermetropia but, because both lenses are less powerful, the difference in spectacle magnification will be less.

**(b)** *Lens form:* the deeper the meniscus (i.e. the higher the base curve), the greater the spectacle magnification. The lenses should be dispensed with the more positive lens in a 'flatter' form than the other. This will reduce the spectacle magnification a little and will also result in the front surfaces of the lenses being more similar in appearance. The lenses can be made to an aspheric design, which is thinner, flatter and lighter.

**(c)** *Lens thickness:* the thicker the lens, the greater the spectacle magnification. The least powerful positive lens can be thicker than normal, so that its spectacle magnification is increased slightly. This will also have the effect of helping to balance the weight of the two lenses. Clearly, the more powerful lens needs to be kept as thin as is consistent with the type of frame or mount used. This will maintain the spectacle magnification and the weight at a minimum. One possibility is to use a higher refractive index material for the thicker lens.

**(d)** *Back vertex distance:* the closer the lens is to the eyes, the less will be the spectacle magnification. It is not possible to mount one lens closer to the eyes than the other but, if the back vertex distance is kept to a minimum, the spectacle magnification for both eyes will be at a minimum and therefore the difference between them less.

**(3)** Contact lenses can be considered, as these provide the greatest reduction in the back vertex distance. It has already been noted that contact lenses also help to overcome the difficulties that arise from differential prismatic effect. Winn and colleagues showed that contact lenses reduce aniseikonia in axial anisometropia as well as refractive anisometropia (Winn et al 1988). Modern lens designs mean that contact lenses are the optimum optical correction for many people with anisometropia (Evans 2006a).

**(4)** Following similar reasoning to that in (3), refractive surgery can be very helpful for these cases (Paysse et al 2004). For high unilateral myopia (−8.00 D to −18.00 D) phakic intraocular lens implants may be appropriate (Lesueur & Arne 2002). In bilateral refractive amblyopia and in unilateral anisometropic amblyopia, laser refractive surgery also seems to bring about an improvement in the amblyopia (Roszkowska et al 2006).

## *Astigmatic corrections*

The above factors can help to reduce the difference in spectacle magnification to a degree where it is unlikely to cause problems in those cases where the anisometropia is mainly spherical. Where the anisometropia is

astigmatic, requiring a higher cylindrical correction in one eye than the other, or where there are high cylinders in both eyes, it is much more likely that there will be disturbances in space perception due to the meridional magnification. The factors mentioned above will assist in these cases, too. Warn the patient of the likely disturbances during the first few days of wearing the new glasses. Consider a partial astigmatic correction and keep the back vertex distance to a minimum.

Lens thickness and form can be employed to overcome the problems in astigmatic corrections by prescribing *isogonal lenses* (Halass 1959). These are lenses whose thickness and surface powers have to be calculated to produce the same spectacle magnification in both meridians of both lenses: there is no difference in spectacle magnification to create aniseikonia. Usually, isogonal lenses need to be made with a toric surface on both sides of each lens, with the principal meridians parallel on each side. This is a very difficult and expensive process and therefore isogonal lenses are only prescribed where other methods of relieving the symptoms of the aniseikonia have failed. An eikonometer is not required for prescribing isogonal lenses.

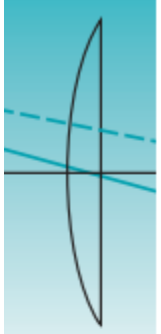
Contact lenses are effective in reducing the problems with astigmatic aniseikonia and, when other factors make the patient appropriate for contact lens wear, this is the most satisfactory method (Evans 2006a).

## Other types of aniseikonia

It is also possible that aniseikonia can be the result of differences that are inherent in the visual system – a difference in the optical system or length of the eyes or an anomaly in the arrangement of the neurones of the two eyes: *anatomical aniseikonia*. These differences are likely to be present at birth, to be present from an early age or to come on very gradually. In many cases, the visual system adapts to the difference and either tolerates it or suppresses one eye. Where suppression occurs, no method of detecting the aniseikonia is available unless the suppression is treated.

Where the aniseikonia is of a degree to be tolerated, it is possible that some change can result in it becoming intolerable and symptoms occur. Diagnosis in these cases requires an eikonometer. A *size lens* (or aniseikonic lens) can be prescribed to give the magnification specified by the eikonometer. As with isogonal lenses, the thickness and surface curves are calculated to give the required magnification. Again, if there is an astigmatic element or if a meridional magnification is required, a size lens will require two toric surfaces.

Because of the cost of making a size lens to a patient's individual prescription, and also because of the indefinite nature of eikonometer readings, trial periods of wearing afocal size lenses are sometimes undertaken. A stock size lens of approximately the magnification required is worn for several days clipped on the patient's normal glasses. It is tried so that it equalizes the image sizes and also for a few days before the other eye so that it increases the size difference. In the first case it should alleviate the



symptoms and in the second make them temporarily worse. This will verify that it is the aniseikonia that is causing the problems and that a size lens would be appropriate to alleviate them. Again, patients should not drive or operate machinery if their spatial perception is significantly altered.

## Clinical Key Points

- Anisometropia over about 1–2 D can cause problems from prismatic effects and/or aniseikonia
- Many patients adapt to their anisometropia, others can be helped by a partial correction
- Problems from vertical prismatic effects are particularly likely with multifocal lenses
- Aniseikonic problems can be reduced by keeping the back vertex distance as low as possible and by careful choice of lens form and material
- Contact lenses provide the best optical solution in anisometropia