MULTIFOCALS FOR CHILDREN

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Children who have a full amplitude of accommodation are sometimes prescribed a reading addition to be dispensed as bifocals or multifocals. This article will explain the reasons for this prescribing decision.

Keywords: Heterophoria, early-onset myopia, bifocals, progressive power lenses

Most children's lenses are dispensed as single vision, but sometimes a child's prescription may include a reading addition. A reading addition may be prescribed
- in cases of convergence excess or accommodative strabismus
- to relieve accommodative spasm
- in an attempt to arrest juvenile-onset myopia.

Heterophoria – a review

Eye position and movement is controlled by a set of six extra-ocular muscles. Under normal circumstances these muscles work together to achieve and maintain comfortable binocular single vision in the primary position and through a range of version and vergence movements.

Binocular single vision is the ability to use both eyes simultaneously so that each eye contributes to a common single perception. It is classified into three stages:

1. Simultaneous perception – the ability to perceive two images at the same time, one formed on each retina.
2. Fusion – sensory fusion is the ability to perceive two similar images, one from each retina, and interpret them as one. Motor fusion is the ability to maintain sensory fusion through a range of vergences.
3. Stereoscopic vision – the perception of the relative depth of objects on the basis of ocular disparity.

Heterophoria

Heterophoria is a condition in which both visual axes are directed towards the fixation point but deviate when dissociated. Orthophoria is rare and the majority of people have some form of compensated heterophoria, which is well controlled and symptom free. Symptoms occur when, for a variety of reasons, the latent deviation cannot be fully controlled and the heterophoria becomes decompensated.

Classification of heterophoria

Esophoria

- Convergence excess. Esophoria is greater for near fixation than for distance.
- Divergence weakness. Esophoria is greater for distance fixation than for near.
- Non – specific. Esophoria does not vary for fixation distance.

Exophoria

- Convergence weakness. Exophoria is greater for near fixation than for distance.
- Divergence excess. Exophoria is greater for distance fixation than for near.
- Non – specific. Exophoria does not vary with fixation distance.

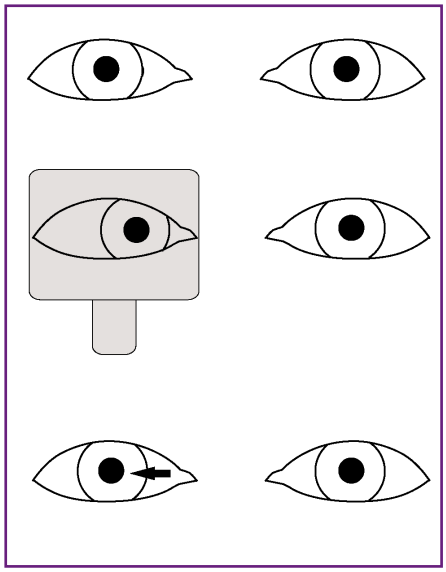

Figure 1: The cover test showing esophoria.
(Courtesy of Linda Rapley)

Hyperphoria/hypophoria

● Vertical deviation in which one eye deviates upwards or downwards on dissociation.

Cyclophoria

● Either eye rotates wheel-like around the sagittal axis on dissociation. Rotation of the top of the globe towards the nose is incyclophoria, away from the nose is excyclophoria.

Detection of heterophoria

Heterophoria can be detected, and measured, by various means. The modern testing room usually carries an array of equipment for such a purpose but the simplest method is the cover test which uses an occluder to dissociate the eyes and elicit the presence of a latent or manifest deviation. Each eye is covered and uncovered in turn and the movement of the eyes to maintain fixation is observed.

When a heterophoria is present it is the eye under the occluder which moves. When the occluder is removed, this eye can be seen to make a recovery movement in order to regain fixation **(Figure 1)**.

For example, when an esophoria is present, the eye under cover moves nasally. The outwards movement of the eye as it regains fixation can be observed when the cover is removed. When an exophoria is present, the eye under cover moves outwards and the returning inwards movement can be observed on removal of the occluder.

Treatment of heterophoria

When control of heterophoria becomes difficult, partial or complete decompensation occurs and symptoms will be produced.

There are many factors which contribute to the decompensation of a latent deviation. These include optical factors such as the non-correction or inaccurate correction of refractive errors, ill-fitting spectacles and aniseikonia. General health conditions and fatigue are also causative factors, as are changes in the demand for accommodation and/or convergence.

Treatment is available in different forms depending on the type, aetiology and severity of the deviation.

1. Refraction. This is often the most important factor in the treatment of heterophoria. In many cases the careful prescribing of appropriate spectacles is sufficient to improve deviation control and alleviate symptoms.

2. Orthoptic exercises. There are a variety of exercises which can be given to improve muscle control and fusional reserves such as bar reading and stereograms.

3. Prisms. These can be used in conjunction with other forms of treatment or on their own. The least amount of prism required to produce comfortable binocular single vision should be used, so that the patient can still use fusional reserves to maintain binocular vision.

4. Surgery. Heterophoria rarely requires surgical intervention but may be an option if the deviation is large or other types of treatment have proved unsuccessful.

The use of multifocals in binocular vision anomalies

Accommodative esotropia

Squints or heterotropias are classified by direction in the same way as heterophorias, by the direction of deviation, and are prefixed in the same way: exo-, eso- and so on. The strabismus or squint can be unilateral or alternating. Accommodative esotropia is an esotropia in which the convergent deviation is affected by accommodative effort. There are two types: fully accommodative esotropia, in which normal binocular single vision (BSV) is present for all distances when the hypermetropia is corrected, and convergence excess, where BSV is maintained for distance fixation, but there is an esotropia at near when accommodation is exerted. Esotropia most commonly occurs in infants or young children with 2.00 – 6.00 D of hypermetropia, and multifocals may be prescribed to relieve accommodation so that the accommodative esotropia does not occur. The Rodenstock Excelit CR39 AS C40 bifocal is designed specifically for this purpose.

Convergence excess

A child's progress at school may be affected if near vision tasks cause ocular discomfort. The child may complain of sore and watery eyes when reading and writing, of headaches, or may cover one eye when reading. This may be attributable to a convergence disorder, either under or over-converging for near tasks. Convergence excess is an uncompensated esophoria which occurs in near vision. If the eyes over-converge for near work, the near phoria may cause symptoms or break down into a convergent strabismus, resulting in diplopia or suppression. This may occur even if there is no distance esophoria.

Accommodation and convergence are linked, and their relationship is described as the AC/A (Accommodative Convergence/Accommodation) ratio. Accommodation is measured in dioptres. Convergence is measured in prism dioptres. It follows that the convergence required to view an object situated midway between the eyes at a certain distance will be greater, the larger the inter-pupillary distance. In order to state the angle through which the eye rotates to view a near object, the inter-pupillary distance (PD) must be known. For example, for an emmetrope with a distance PD of 60mm (6cm) viewing an object at one metre, the angle of convergence for each eye will be 3 x 1 D. Accommodation for one metre distance will be +1.00D, so the AC/A ratio will be 3:1. Individuals with convergence insufficiency will have AC/A ratios of less than 3:1, and those with a convergence excess esophoria will show AC/A ratios of greater than 5:1. It is common to relieve a decompensated heterophoria with the use of prisms, but in the case of a convergence excess esophoria, base out prisms tend to cause the esophoria to increase with time, so rather than incorporating base out prism, the accommodation/convergence relationship can be utilised by reducing the accommodative demand, and hence the convergence, through the provision of a reading addition, and to maintain BSV at near. This may be as a bifocal, trifocal or PPL or dedicated near single vision prescription. Over time, this addition can usually be reduced or eliminated.

Accommodative spasm

This may occur if there is an increase in the duration and frequency of close work, and is not uncommon in children or young adults who may be studying intensively prior to an examination, or who return to study after a long holiday period. If the accommodative effort cannot be maintained, symptoms occur. It may arise when there is latent hyperopia, which requires a cycloplegic examination for it to be revealed, or in manifest low hyperopia. Bifocals or multifocals, with or without a positive distance correction may prevent the spasm and restore near visual comfort.

Occasionally the spasm causes apparent myopia or pseudomyopia, in

which the child will appear to be myopic during subjective refraction, but emmetropic or hyperopic if a cycloplegic examination is performed.

Myopia

A term sometimes used for the type of myopia which develops early in life is 'juvenile stress myopia' [1]. 'Juvenile-onset myopia' is a more appropriate description. Juvenile-onset myopia results from axial elongation of the eye, which may or may not be caused by ocular stress. Many studies have concentrated on investigating the established link between myopigenesis and near work [2,3]. Epidemiological studies have indicated that the largest incidences of myopia occur in societies where there is a rigorous educational system [1], such as Singapore and Hong Kong. There is now an established link between the development of myopia and near work, and also with accommodation and/or convergence function. Gwiazda *et al* [4] showed that myopic children under-accommodate at near, compared with emmetropes (accommodative lag), and show a high AC/A ratio. Goss and Wickham [5] in 1995 reviewed studies which investigated the hypothesis that retinal image defocus is biochemically transformed into a signal for increased posterior segment growth. These factors can be linked by the suggestion by Gwiazda that an esophoric child (high AC/A ratio) must relax accommodation in order to maintain binocular single vision at near; the accommodative lag results in defocus, which in turn could feedback signals to the growth mechanism of the eye, producing axial elongation. Heritability is also a major factor in the development of myopia. Lyhne et al found a heritability index of at least 89% for refractive error [6], and Mutti *et al* [7] found that children whose parents were both myopic were six times more likely to become myopic than those with emmetropic parents.

Methods used to arrest the progression of myopia are varied, ranging from special diets to strengthening the posterior globe by the injection of polymers. The most frequently researched methods are the paralysation of the ciliary muscle with cycloplegic drugs, the provision of multifocal spectacle lenses compared with single vision, alone or in combination with drugs, contact lenses or vision therapy. The latter two will not be included here.

Ophthalmic drugs

In the pharmaceutical category, drugs which affect the ciliary muscle or the intra-ocular pressure have been investigated. (An increase in intra-ocular pressure when the eye accommodates has been suggested as a possible factor involved in axial length elongation). Tropicamide (a cycloplegic/anti-muscarinic) or timolol (a drug which reduces intra-ocular pressure) had no significant clinical effectiveness for the arrest of myopia [8]. However, the cycloplegic/antimuscarinic Atropine was found to be effective [9,10,11], with benefits remaining after treatment was discontinued. Pirenzipine is a relatively selective anti-muscarinic, with less adverse effects than atropine. It was used in a recent one-year trial in Asia, which showed a significant decrease in myopic progression [12]. The accommodative effects were relatively mild.

A smaller trial, with similar results, was conducted in the USA [13].

Single vision lenses

Overminus correction and its effect on myopic progression was considered as part of research trials on subjects with convergence insufficiency, in which an overminus reading correction was employed to stimulate accommodative convergence. It has also been directly investigated with existing myopes. Although a study by Caltrider and Jampolsky [14] in 1983 reported a myopic increase of 1.00D or more in 43% of their subjects, when using overminus therapy for exotropia, later studies have shown that overminus correction slightly increased or had no effect on myopia, compared with the normal population [15,16]. In all the literature reviewed, the only method of attempted myopia retardation which speeded up the progression – was under-correction [17]. Single-vision lens wearing patterns of myopes showed no clinically significant effect on refractive error with full-time wear, part-time or no wear [18].

Bifocals

In a 1994 literature review of the effects of bifocal wear on myopia progression, results were found to be widely variable, but in other studies there was evidence that, when combined with esophoria, control was effective with the provision of bifocals [19,20]. The Fulk et al study used an addition of +1.50 in a flat-top bifocal segment. Another study of theirs also showed that the rate of progression was greater during the school year [21], which seems to support the link between close work and myopia. In 2002, Saw *et al* [8] reviewed research papers investigating the effectiveness of bifocals with various near additions and found that there was no difference between the effectiveness of any particular powers. Atropine combined with the use of multifocal lenses appeared to be the most successful treatment for slowing the rate of, or halting, myopic progression [22,23], and in a study [24] using atropine and photochromic bifocals with a +3.00 addition, there was a decrease in myopia. The same study also showed that constant wear was the most effective wearing pattern.

Progressive power lenses

It was found in a study published in 1999 that progressive power lenses (PPLs) were effective in slowing the rate of myopia progression [25]. Schoolchildren who wore an addition of +2.00 had a slower rate of progression than those who wore a +1.50. In a paper revisiting their study, Brown, Edwards and Leung [26] observed that there was only 46% as much myopic progression in the esophoric children who were part of the trial. The results from three years of the five-year COMET (Correction of Myopia Evaluation Trial) study of young myopes were published in April 2003 [27]. This showed that the use of Varilux Comfort PPLs slowed myopia progression by a small but statistically significant amount. However, the authors concluded that the effect did not warrant a change in clinical practice. As yet there have been no clinical trials which compare the relative merits of differing PPL designs on the retardation of myopia.

Discussion

It may be significant that the above instance of bifocals combined with cycloplegia slowed or reversed the rate of myopic progression in a similar way to a PPL. Bifocals or trifocals reduce the amount of accommodation for near vision tasks, but for viewing objects between the far point and the near/inter working distance, accommodation must still be exerted for clear vision. Another factor which should be considered is that children's arms are shorter, and a study by Rosenfeld *et al* [28] showed that the mean working distance for children between 6 and 11 years old was 27.2 cm. Most adult additions are assessed at 40cm, but, for children, the authors of that study recommended that the reading addition should be assessed at the more appropriate distance of 25 cm. A near addition of +2.00, as was the maximum addition in the PPL studies, would still leave children accommodating for near work. A high addition PPL lens, with its gradually increasing addition provides the opportunity for less or no accommodation at any distance.

Dispensing multifocals to children

A large flat-top, curved top or E-line is usually chosen. Some practitioners prefer to dispense a large round segment, because it is less noticeable. However, the jump at the dividing line of such a segment might cause adaptation problems for the child.

Figure 2 shows how it is recommended a bifocal should be fitted for a child, using a flat-top bifocal as an example. It is fitted as a trifocal would be fitted for an adult – with the segment top midway between the lower edge of the iris and

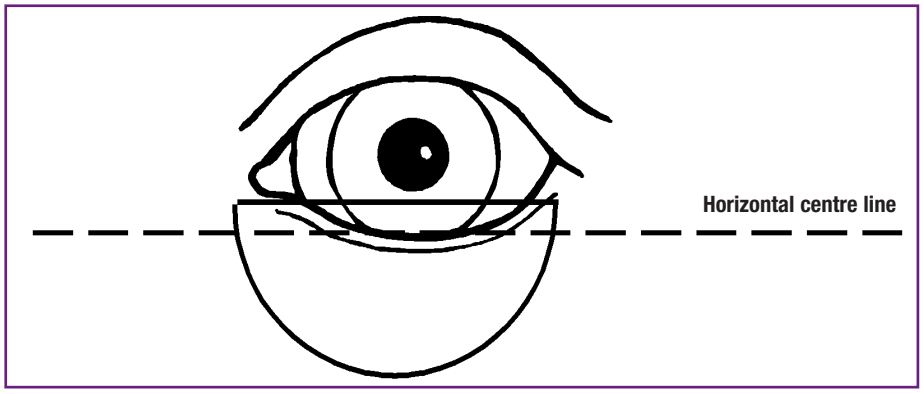

Figure 2: Fitting a flat-top bifocal, child's fitting.

the centre of the pupil in primary distance gaze, although it is acceptable to set the dividing line as high as the centre of the pupil [29]. The horizontal centre line of a correctly fitting frame will lie along the lower edge of the iris. Children's frames can be very small, and if the HCL lies lower than this position, the incorporation of the segment can leave very little area above the segment for distance vision. When dispensing for an adult, the concern is that the segment will have enough depth for an acceptable vertical field of view: a height of 12mm is generally accepted as the minimum segment depth for non-occupational-specific use. However, with children's bifocal fitting, there are several objectives:

- the segment should be wide enough so that the child cannot peep round it
- the segment should be easily found when the child looks down to read
- the segment should be high enough to discourage lowering the head to view close work through the distance portion
- the segment should be low enough to leave enough distance portion depth

Considering an eyesize of 40 x 26, where the HCL lies 13mm above the lower rim, it can be seen how close a segment dispensed to a child is to the adult's recommended minimum segment height. For this eyesize, if the segment is fitted 2mm above the lower edge of the iris, ie 2mm above HCL, the segment depth will be 15mm, and the distance portion depth will be 11mm. In such a case, it would be sensible to fit the frame, by bridge sizing or adjustment so that the HCL will lie a millimetre or so above the lower iris position: ideally, in this case, so it coincides with the segment top. The segment top position ordered would be zero, and the maximum depth possible is then provided for distance and near. If the child has a well-developed bridge crest, the pantoscopic tilt should be increased to ensure that it is made difficult for the child to look under the spectacles to read and write. If the child is young, the bridge will be flatter than that of an adult or older child, and if fitted correctly the vertex distance will be small, which will also prevent viewing under the lower rim. Larger eye sizes will give more flexibility in the segment position, and shallow frames should be avoided, unless a deeper frame causes pressure on the cheeks. In the studies using PPLs, no detailed reasons were given regarding the selection of the type of PPL used. Apart from the consideration of whether a hard or soft design is preferable, and the corridor length is appropriate, the power profile should be considered. The power profile of many PPLs shows the power increase due to the reading addition beginning just above the fitting cross, resulting in a slight under-correction for distance when viewing through the fitting cross. Under-correction is not desirable, and therefore care must be taken to select a lens whose power profile shows a start point for the near addition power increase as near to the fitting cross as possible. Although no guidelines have appeared which are supported by research, it is assumed that the children who were part of the clinical trials mentioned previously were fitted so that the fitting cross coincided with the pupil centre in primary distance gaze. Therefore it is suggested that when fitting a progressive power lens to a child, the fitting cross should be at the pupil centre, the same way as for an adult dispense, with due consideration of the useful lens area above the fitting cross position. The lens material should have good impact resistance, such as polycarbonate, PNX, and Trivex. Trivex is available from Norville as the Trilogy Image compact progressive, Trilogy single vision (S/V), Trilogy Aspheric, and Trilogy Xare (S/V reflection free). The Image and the Trilogy S/V aspheric are also available in Transitions. PNX is available from Hoya in single vision and the Summit Pro PPL. Taylor Optical also supply Trivex lenses.

Conclusion

Now established as a reliable treatment for some binocular vision anomalies, as described in the first part of this paper, the use of multifocals in the management of myopia remains controversial.

The high number of studies on this topic, with various and sometimes conflicting conclusions shows that, as yet, there has been no clear management pathway which will arrest myopia in all cases when there is juvenile onset. Measures which prevent accommodation by various means are more successful than those using single vision lenses or methods which reduce intra-ocular pressure, and it is suggested by the authors that, in practice, where the prescriber may be reluctant to consider a management plan for children involving ophthalmic drugs, the provision of an add for juvenile-onset myopia may have better success if high add PPLs are dispensed, rather than bifocals, for constant wear. In addition, PPL management of children who are esophoric and myopic may slow, arrest or retard the progress of their myopia. However, there is a need for further studies using PPLs with higher additions than +2.00.

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