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CPD CODE: C-107734

MCQs AVAILABLE ONLINE:
Friday 1 March 2024

CLOSING DATE: 7 June 2024

ANSWERS PUBLISHED:
July/August issue 2024

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CPD CODE: C-107734

The effect of uncorrected refractive error and refractive correction in binocular vision issues

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Binocular vision anomalies can be caused by numerous issues that place stress on the visual system, causing misalignment. This CPD article looks at uncorrected refractive error as a cause of binocular vision issues, and how refractive correction can be used and modified to aid in the correction of heterotropias and heterophorias. After reading this CPD article, you should be able to:

- *Discuss how refractive error can affect the binocular vision system*
- *Discuss the management options for refractive heterotropias and heterophorias*
- *Discuss how binocular vision issues may affect refractive correction prescribing*

INTRODUCTION

Uncorrected refractive error or inaccurate refractive correction can have a role in determining the severity and/or type of a binocular vision (BV) issue. In most of these cases, this is related to the relationship between accommodation, refractive error and vergence. Treatment of these conditions is important to aiding normal development of the visual system.

Whilst there are many causes of BV anomalies, this CPD article will examine the several types of BV issues related to refractive error that present in clinical practice – and how they can be managed as part of a multi-disciplinary team. It will also discuss how, in rare circumstances, the exacerbation of a latent BV issue can manifest itself through non-tolerance to spectacles.

TERMINOLOGY AND DEFINITIONS

Heterophorias and heterotropias are common BV issues found in optometric practice. A heterophoria is a latent deviation of the eyes, which normally only presents through dissociation of the two eyes. A heterotropia, also known as a strabismus or squint, is a manifest deviation of the eyes, meaning it is present without dissociation of the two eyes[1]. If no heterophoria or heterotropia is detected, the patient is deemed to have orthophoria.

The majority of patients encountered in practice will have a phoria that is symptomless. This is referred to as a 'compensated heterophoria' and no management is required. However, some heterophorias can become decompensated, which leads to the heterophoria becoming a heterotropia when the vision system is under stress[2]. Uncorrected refractive error is one of the many factors, including ergonomics or muscle imbalance, that can lead to this occurring.

When considering horizontal heterophorias and heterotropias 'exo' misalignments refer to the affected eye moving out relative to the aligned visual axis. These are referred to as an exotropia (XOT) or exophoria (XOP). For eso misalignments, the affected eye would move in and would be referred to as an esotropia (SOT) or esophoria (SOP)[1].

This article predominantly deals with horizontal heterophorias and heterotropias. Vertical misalignments of the visual axis, hyper and hypo phoria and tropia do not tend to be refractive in origin and so are not examined.

However, vertical misalignment can still occasionally present as cases of non-tolerance to spectacles[3].

PREVALENCE AND ASSOCIATIONS

A 2009 study in Australian schoolchildren aged six to 12 years of age reported that more than 85 per cent of the 3,981 participants had orthophoria at distance fixation[4]. XOP was most prevalent for near fixation varying between 52-58 per cent of participants depending on their age. SOP was far less common, with 10 per cent of participants presenting at near and less than one per cent when fixating at a distance target. XOP was associated with myopia and SOP associated with hyperopia.

A study in West Yorkshire investigated the prevalence of heterotropias in the area from 2012 to 2015 in a population of 17,018 children aged four to five years of age[5]. Overall, 2.4 per cent of the children examined had a heterotropia, with 53 per cent having an XOT and 45 per cent having an SOT. SOT was associated with hyperopia, while the development of XOT was not associated with refractive error.

MEASUREMENT OF HETEROPHORIAS AND HETEROTROPIAS

BV status is routinely checked during eye examinations. The most common assessment is done by the cover test, which involves covering eyes in turn to determine whether a heterotropia or heterophoria is present[6]. A prism bar can be used in conjunction with the cover test to measure the size of any deviation. The size of a deviation is measured in prism dioptres.

Other methods can be used to measure heterophorias and heterotropias including Maddox rod[7] (**Figure 1**), Maddox wing[8] and the Thorington cards[7]. If a BV issue is suspected, these methods should be used to measure the size of the misalignment with no correction, habitual correction (if required) and the new refractive correction to see what effect refractive correction has on the BV system.

Possible fixation disparity needs to be considered when measuring symptomatic heterophoria. This occurs when there is a small misalignment between the eyes where images do not fall on the corresponding retinal points of the two eyes, however, the image is still single as they have fallen within Panum's fusional area[9].

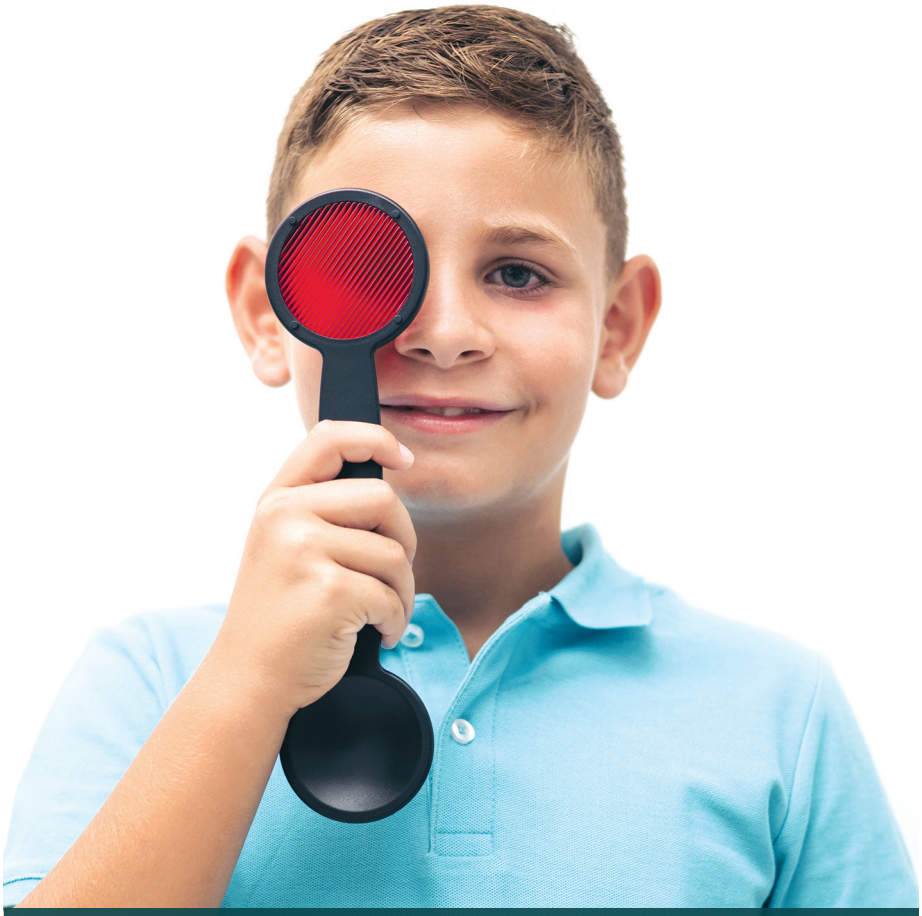

FIGURE 1. A Maddox rod can be used to measure heterophoria and heterotropia

Fixation disparity is regarded as a sign of stress on the BV system and is therefore associated with decompensated heterophoria. Its effect can be assessed by measuring the 'associated heterophoria' or 'aligning prism'. This is the amount of prism that is required to neutralise fixation disparity.

Instead of having complete dissociation between the eyes, as in the cover test or Maddox rod mentioned previously, some fusion needs to be allowed when measuring associated heterophoria. The Mallet Unit test does this by allowing partial fusion between the two eyes, whilst ensuring that there are targets that can only be seen monocularly[2].

TREATMENT STRATEGIES OF HETEROPHORIAS AND HETEROTROPIAS

For the majority of heterophorias and heterotropias there tends to be a standard hierarchy of treatment options in encouraging proper function of binocular vision[2,10]. The first consideration is what might be the cause of decompensation.

For example, the working distance of a patient, depending on the type of heterophoria they have, may be a cause of exacerbation. Once this has been considered, refractive correction is the next area of attention. If refractive correction cannot solve the issue, orthoptic exercises may be prescribed to treat any potential muscle weakness such as in convergence insufficiency. If none of the preceding options have had the desired effect, then prismatic correction may be required. The measurement of associated heterophoria can be used to determine the amount of prism required to treat a decompensating heterophoria.

Finally, in cases where decompensation cannot be relieved with any the proceeding methods of treatment then referral may be required for surgical intervention. These methods of treatment depend on a range of factors depending on the type of BV anomaly and any accompanying secondary conditions.

TYPE	CHARACTERISTICS
Convergence excess	Esophoria at near > esophoria at distance
Divergence weakness	Esophoria at distance > esophoria at near
Basic	Esophoria at distance and near approximately equal
Convergence weakness	Exophoria at near > exophoria at distance
Divergence excess	Exophoria at distance > exophoria at near
Basic	Exophoria at distance and near approximately equal

TABLE 1. Characteristics of the different types of horizontal heterophoria

HOW DOES UNCORRECTED REFRACTIVE ERROR AFFECT HETEROPHORIAS AND HETEROTROPIAS?

One of the key aspects to understanding the relationship between BV issues and uncorrected refractive error is appreciating the role of the accommodation and vergence systems. In a normal BV system, for every dioptre needed to accommodate the eyes should converge by approximately three to four prism dioptres. This is referred to as the accommodative convergence /accommodation (AC/A) ratio[11,12].

This system allows for comfortable vision as the more the eyes need to accommodate it can be assumed that a near target has moved closer and therefore the eyes need to converge more. In uncorrected refractive conditions, this can lead to an abnormal vergence response due to a relatively increased or reduced change in vergence caused by an inaccurate accommodative response.

If a patient has a high AC/A ratio, it means that their eyes are converging more than normal for the accommodative demand; whereas if they have a low AC/A ratio, it means that they are converging less than is expected.

In uncorrected hyperopia, pre-presbyopes can accommodate to maintain clear vision, however, this leads to the eyes over-converging, which would present as an esophoria which may break down into an SOT.

In uncorrected myopia, a patient may have an XOP at near due to under converging of the eyes. This is due to the vision system not having to accommodate as much as when the refractive error is fully corrected. The decrease in the accommodative response will therefore lead to a decrease in the amount of convergence associated with accommodation.

In cases of fully corrected hyperopia and myopia, we can assume that any residual phorias would be like that of an emmetrope if there is no other cause for misalignment.

PHORIAS

Horizontal heterophorias can be further subdivided into different classes of SOP and XOP (**Table 1**). SOPs can be described as a convergence excess SOP, where the magnitude of the deviation is greater at near than distance, or a divergence weakness SOP, where the deviation is greater at distance than near.

Similarly, XOPs can be classified as convergence weakness where the deviation is greater at near, or divergence excess where the deviation is greater at distance. In cases where the size of a deviation is similar at distance and near then the SOP or XOP can be termed as basic.

Whilst it is important to note that the majority of heterophorias are compensated and don't require a management strategy, refractive correction may aid cases of decompensated heterophorias.

Generally, in all the types of heterophoria mentioned above, the effect of refractive correction is normally investigated following consideration of any potential ergonomic factors causing or contributing to decompensation. It is also important to note that, in some cases, it may require a combination of treatments to result in a compensated heterophoria.

Esophoria

When refractive correction is required in cases of SOP, it is usually associated with uncorrected hyperopia. In many cases, the full plus prescription is not given with a reduced refractive correction considered. This may be due to difficulty adapting to the full prescription, which in younger patients can be used to encourage emmetropisation, the process by which the usual hyperopic refractive error present in infancy develops towards emmetropia[13,14].

Fully corrected hyperopia in young children would reduce the chances of this happening. There are still different opinions on how much to reduce hyperopic prescriptions by[15]. A clinician needs to weigh up the effect on visual acuity along with effect on the SOP considering the minimum amount of plus required to eliminate the decompensation element of the SOP.

In cases of convergence excess SOP, a near addition can be incorporated in a multifocal prescription[2]. Convergence excess SOP is associated with a high AC/A ratio. The add, in this case, will reduce the amount of accommodation required and, therefore, reduce the over-convergence that presents as the larger SOP at near fixation. The aim here is to reduce the add over subsequent visits to the point where the patient can control the heterophoria themselves.

Exophoria

A similar approach can be considered in cases of convergence weakness XOP. In this case, a negative add can be introduced in cases where the full prescription on its own or orthoptic exercises have not been successful. Similar to the positive add in convergence excess SOP, the negative add would be gradually reduced with the preferred outcome being the patient having control over the remaining XOP. Aside from that, for myopes with XOPs, a full myopic refractive correction can prove helpful.

More care is required with hyperopes with a decompensating XOP. Here, the full prescription can potentially make the XOP worse so a partial correction may be required. In all cases of SOP and XOP, the effect that the new prescription has on the heterophoria should be measured to determine its effect in aiding compensation. It is advisable to leave the prescription in place for a few minutes before doing this to consider any adaptation to the lenses.

ACCOMMODATIVE ESOTROPIA

Accommodative SOT is associated predominantly with hyperopia and to a lesser extent, astigmatism[16-19]. Accommodative SOT can be divided into fully accommodative and partially accommodative. Fully accommodative SOT can be corrected entirely using refractive correction[20] whereas partially accommodative SOT will require further treatment in addition to full refractive correction[19]. The normal development of stereoacuity has been shown to be affected by accommodative SOT[21].

Non-compliance of treatment in accommodative SOT has been shown to affect the long-term motor and sensory outcomes – so children and parents of children should be encouraged to comply with treatment from the outset[20]. This is especially essential in younger children where accommodative SOT is correlated with the development of amblyopia[22] (**Figure 2**).

ACCOMMODATIVE ESOTROPIA AND AMBLYOPIA

Amblyopia is a condition where the best corrected visual acuity is reduced either in one eye or both that occurs during visual development in the first six to seven years. The most common causes of amblyopia include anisometropia, heterotropia or visual deprivation caused by congenital cataract[1]. Anisometropia tends to be the most prevalent cause of amblyopia, however, there is some form of strabismus in approximately 46 per cent of cases[23]. In these cases, the accommodative SOT usually develops around the age of two-and-a-half and development can range from 18 to 48 months[24-26].

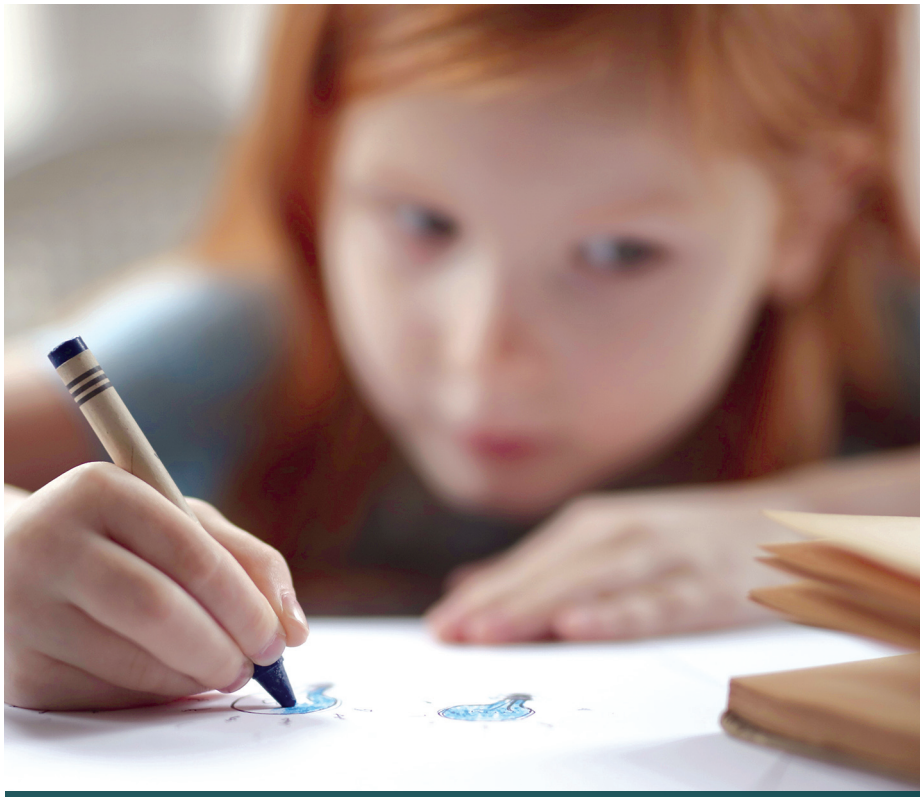

FIGURE 2. Accommodation takes place for everyday activities for children

Generally, the effective treatment window for amblyopia ends around the age of seven years, though it has been suggested that this may be longer than previously thought with evidence of ocular plasticity in some studies up the age of 15[27].

Whether the amblyopia is anisometropic, strabismic or both in origin, full refractive correction is the first line of treatment. In some cases, it can lead to the resolution of the amblyopia without the need for further treatment, such as occlusion therapy. However, in cases where refractive correction does not lead to resolution on its own, it is still considered a vital first step before other forms of treatment are considered[27].

It has been suggested that refractive correction in the first instance improves the likelihood of subsequent therapies like occlusion being more successful[28]. In cases of amblyopia with a partial accommodative SOT, it has been suggested that early wearing of a full-time hyperopic prescription can significantly decrease the need for surgery at a later date[29].

Given the advantages refractive correction can have in amblyopic cases, compliance is key. The wearing of spectacles tends to be more amenable than that of wearing a patch[30], however, it is still necessary to encourage full-time wear of spectacles in these situations.

INTERMITTENT EXOTROPIA

Intermittent XOT is the most common manifestation of XOT in children. As the name suggests, this type of XOT does not manifest constantly, tending to do so under conditions that cause stress to the visual system like bright sunlight, inattention, fatigue or under ill-health[31]. Double vision is not usually reported as the deviating eye is suppressed when the XOT is manifesting[32].

As mentioned earlier, uncorrected refractive error does not tend to be related to the development of XOTs[5], however, the use of minus lenses has been shown to lead to successful outcomes in patients with intermittent XOT[33].

Minus lens therapy works by the addition of the minimum minus power up to maximum of -4.00D required to control the XOT to the already fully corrected refraction result[10]. Amplitude of accommodation would need to be measured to ensure that accommodation can be used comfortably during this process.

Following this, the minus lens power is reduced in -0.50 D steps every six months, subject to the patient demonstrating control of the intermittent XOT, to gradually encourage binocularity when the treatment has concluded. The increased minus power encourages accommodative convergence causing the magnitude of the XOT to reduce. Orthoptic exercises may need to be combined with the therapy as well[10].

Research has suggested that this form of treatment can lead to intermittent XOT resolving in approximately 50 per cent of cases[33]. Surgery may be required in unresolved cases, however, minus lens therapy allows for continuing BV in the period prior to surgery. Previously, there has been concern that minus lens therapy may lead to the development of myopia, however, numerous studies have suggested that this is not the case[34-36].

NON-TOLERANCE ISSUES

Non-tolerance to spectacles can be caused by many issues, with the vast majority being prescription or dispensing related[3,37]. In studies examining the proportion of causes of non-tolerance to spectacles, BV issues feature either relatively rarely compared to other causes[3,37] or not at all[38] – with causes such as cylindrical changes or a prescription being over-plussed or under-minused having a far greater prevalence.

Inaccurate prescribing can potentially lead to symptoms, which may present as non-tolerance to a new pair of spectacles or recently changed contact lens prescription. For instance, in cases where a patient has been over-minused, it could potentially lead to what was a previously compensated SOP becoming decompensated, as accommodation needs to be used to make up the difference in refractive error.

An increased accommodative response leads to over-convergence causing an increase in the magnitude of an SOP. Younger patients, having a larger amplitude of accommodation than older patients, would be more susceptible to this. However, it is important to note that in these cases the patient would have to be excessively over-minused for this to occur.

During refraction, there are several safeguards in place to prevent this from happening. Practitioners are encouraged to 'push the plus' to ensure that over-minusing does not occur. Using this technique, minus is only added if it improves visual acuity.

One method of checking that a patient is not over-minused is to add +1.00D lens in each eye[39]. If a reduction in VA is not observed when this lens is added, it would suggest that the patient has been over-minused and the patient should be offered more plus to see if they can tolerate it. Heterophorias should also ideally be measured before and after refraction to ensure that there has not been an excessive negative change in the magnitude of a heterophoria.

Prescribing may need to be adjusted for hyperopes with exo-deviations. Giving the full prescription in this case may exacerbate symptoms in a decompensating XOP. Under-correction of hyperopia in this case may be helpful as the increased accommodation needed to make up for the under-correction will lead to the eyes converging more than if fully corrected, and thus reducing the magnitude of the XOP.

CONCLUSION

This article has sought to look at the effects that uncorrected refractive error and refractive correction has on the binocular vision system. It can be concluded that uncorrected refractive error can lead to the development of some binocular vision issues.

Refractive correction can be used to correct binocular vision anomalies – and where necessary can be used in combination with other treatments. Whilst rare, it is important to consider the effect that the inaccurate prescribing or dispensing of spectacles can have on the binocular vision system.

REFERENCES

References can be found when completing this CPD module. For a PDF of this article with references, email abdocpd@abdo.org.uk

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LEARNING OUTCOMES FOR THIS CPD ARTICLE

DOMAIN: Communication

2.1: *Appropriately communicate management options for refractive heterotropias and heterophorias with patients and their parents/carers as required.*

DOMAIN: Clinical Practice

5.3: *Be aware of current good practice in relation to refractive prescribing for binocular vision issues and the management of refractive heterotropias and heterophorias.*

7.5: *Provide effective care to patients with binocular vision issues within your professional scope of practice.*

COMMUNICATION

CLINICAL PRACTICE

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