**An active ciliary body controls the eye’s accommodation process, allowing near focusing to occur. The ciliary body is made up mainly of smooth muscle, known as the ciliary muscle. Accommodation occurs when the muscarinic receptors within the ciliary muscle are stimulated by the parasympathetic neurotransmitter, acetylcholine (see Part 1 Optician 29.06.12). The ciliary muscle then contracts, pulling the ciliary body forward. Tension in the suspensory ligaments supporting the crystalline lens is reduced. As a result, the lens becomes more convex, and thereby increases its refractive power. Adequate focus for nearer targets is then achieved.**

To obtain the true distance correction, it is imperative that refraction takes place when the patient has relaxed his/her accommodation. For most adults and some children, this can be achieved by directing the patient to view a non-accommodative distance target. However, in some individuals, particularly the young, this is not sufficient and other methods must be employed to ensure an accurate result.

Cycloplegia means ‘paralysis of the ciliary body’. In this state, the eye cannot accommodate and the latent prescription can be determined.

To obtain cycloplegia, practitioners use drugs known as cycloplegic agents. These are muscarinic antagonists which block the muscarinic receptors within the ciliary muscle (muscarine is a chemical that early neurology researchers found to effectively block the acetylcholine receptors at the post ganglionic neurone action site of the parasympathetic system). If acetylcholine can no longer reach the ciliary muscle, accommodation cannot occur.

Cycloplegic agents are particularly valuable within paediatric optometry (Figure 1). They are also beneficial beyond this age group when examining patients with particular refractive needs. Furthermore, cycloplegia is occasionally desirable for patients receiving ophthalmological care. This article explores the diagnostic uses of cycloplegic agents, touches on their therapeutic applications and considers alternatives to their use.

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**Indications for cycloplegia**

### Latent hypermetropia

In young individuals, hypermetropia is often masked by the use of highly active accommodation. The eye achieves reasonably clear vision by using its accommodative system to overcome its ametropia. When a hypermetropic eye accommodates, it brings the far point of focus closer to the retina, thus obtaining a less blurred image.

Unfortunately this can induce increased convergence, which may result in an unstable esophoria, or an esotropia, leading to strabismic amblyopia. A cycloplegic refraction is therefore essential in all infants and children who have a manifest deviation, a high or unstable esophoria or a positive history of an eye turn.

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**Poor acuity and/or stereopsis**

In paediatric patients, these can be indicative of amblyopia, potentially caused by uncorrected hypermetropia, astigmatism, anisometropia or strabismus. To fully investigate the cause, a cycloplegic refraction is recommended.

### Family history of squint, amblyopia or hypermetropia

A child is predisposed to these conditions if a positive family history exists. Should this be the case, due to the potential risk of amblyopia, it would seem sensible to fully investigate the child’s refractive status by performing a cycloplegic refraction.

### Concentration difficulties

Use of a cycloplegic agent reduces the need for a patient to concentrate on a distance target to allow static retinoscopy to take place. This may be beneficial in hyperactive children or patients with physical or mental disabilities.

### Poor accommodation

Decreased levels of accommodation may be found in individuals with uncorrected hypermetropia, amblyopia, or oculomotor nerve problems. Additionally, there is clear evidence that in children with Down’s syndrome and cerebral palsy under-accommodation is considerable. If an unexplained reduction in accommodation levels is discovered, a fuller investigation of the problem may be made through use of a cycloplegic agent.

### Pseudomyopia

Pseudomyopia occurs when a spasm of accommodation causes the muscle tone...
within the ciliary body to be greater than is necessary for the viewing distance. The ciliary muscle is not relaxed, even for distance targets, giving the impression of myopia. The accommodative spasm can be induced by prolonged close work and is also associated with stress. Dispensing a myopic prescription may encourage more spasm. Pseudomyopia should be considered when the patient’s amplitude of accommodation is unexpectedly low, and if a noticeable esophoria exists (due to the relationship between accommodation and convergence). Releasing the spasm of accommodation by use of a cycloplegic agent allows a more accurate prescription to be determined. If this prescription demonstrates a reduction in myopia, a diagnosis of pseudomyopia is fairly clear. In some cases an appropriate prescription will be given. However, this may not be tolerated as, in its post cycloplegic state, the eye reverts to pseudomyopia. If this occurs, instillation of a cycloplegic agent to relax the accommodation while the patient adapts to the new prescription, can be useful.

Malingering/visual conversion reaction (VCR)

Malingering has been defined as the ‘wilful, deliberate and fraudulent feigning or exaggeration of symptoms of illness or injury done for the purpose of a consciously desired end’.6 VCR describes an unconscious process whereby a psychosomatic response results in visual symptoms, sometimes referred to as ‘hysteria’.7 In either case, a cycloplegic refraction may reassure the practitioner ‘hysteria’.7 In either case, a cycloplegic refraction may reassure the practitioner that the subjective findings are not caused by a significant refractive error.

Refractive surgery

Cycloplegic refractions in adult patients have become more widespread in recent years due to the increasing popularity of refractive surgery. When any sort of surgical correction of ametropia is considered, it is vital that the absolute refraction is known. If pseudomyopia is suspected, or if hypermetropia exists, a pre-surgery refraction should include the use of cycloplegia. This helps avoid the undesirable outcome of under/over correction.8

During adaptation to a new hypermetropic prescription

If a decision has been made to give a new or increased hypermetropic prescription, a child’s overactive accommodation may blur the vision through the new glasses. If this occurs, temporary cycloplegia may assist with adaptation to the new prescription by reducing the accommodation and thereby improving acuity.

Amblyopia therapy

Cycloplegia can also be useful as a form of penalisation as part of amblyopia therapy.9 This method of treatment has been found to be as effective as conventional occlusion10 and can be particularly useful for patients who are intolerant to patching.11 Use of atropine ointment (1 per cent) in the good eye reduces its usefulness for near focusing. The amблиopic eye (with appropriate spectacle correction) is therefore encouraged to concentrate at this distance instead. Care should be taken to avoid occlusion amblyopia12 and this technique is not recommended in infants less than 18 months old.

In ophthalmology

Cycloplegic agents are prescribed in anterior uveitis.13 They allow relaxation of the inflamed ciliary body and produce mydriasis which can reduce the formation of posterior synechiae and relieve pain of spasm.

Correct procedure

Prior to instillation

A thorough history and symptoms should be taken to ensure that the patient has no known allergy to the cycloplegic agent. Caution should be exercised in administering cyclopentolate to individuals known to have experienced CNS disturbances, especially following closed head trauma. Some practitioners hold a view that sensitivity to cycloplegics is increased in patients with Down’s syndrome and cerebral palsy.14 Interestingly, Nandakumar and Leat reported no adverse reactions to 1 per cent and 0.5 per cent cyclopentolate in their examination of children with Down’s syndrome, although they did note that pupill dilation due to cyclopentolate was greater in the study population than that reported in children without Down’s syndrome.3

An investigation of unaided visions, muscle balance and accommodation should be made prior to instillation. Intraocular pressures and anterior chamber angles should also be assessed where appropriate.

The patient and parent/guardian, if applicable, should be made aware of the effects of the drug. Careful timing of the procedure should be considered to avoid undue inconvenience to the patient while the cycloplegia and mydriasis subside. Information should be given regarding symptoms of angle-closure glaucoma and patients who drive should be advised to refrain from doing so until the effects of the drops have worn off.

A sensible choice of cycloplegic agent should be made. Typically, this will be cyclopentolate hydrochloride, available in 0.5 per cent and 1.0 per cent solutions. 0.5 per cent should always be used with infants under the age of six months. It may also prove useful with fair skinned individuals (who have less iris melanin) over 12 years of age. For all other patients, the 1.0 per cent solution should be used.

Use of 1.0 per cent tropicamide can provide limited cycloplegia if two drops are instilled, five minutes apart. However, if retinoscopy does not take place immediately, a further drop should be instilled after 35 minutes. This method can provide sufficient cycloplegia in patients in their late teens and above. Manny, Hussein et al15 have also demonstrated that tropicamide 1.0 per cent is an effective cycloplegic agent in myopic children, while Twelker and Mutti16 presented tropicamide 1.0 per cent as a viable alternative to cyclopentolate in most nonstrabismic infants. A combination of tropicamide 0.5 per cent and phenylephrine 0.5 per cent was found to be effective for cycloplegic refractions in nonstrabismic children and those aged older than five years by Fan, Rao et al.17

Atropine sulphate 1.0 per cent is usually only chosen if cyclopentolate has not produced adequate cycloplegia or prolonged penalisation is required. It must not be used on infants under three months of age as its prolonged action renders the infant at risk of stimulus deprivation amblyopia. Should a practitioner be of the opinion that the use of atropine would be beneficial in a particular case, he or she may refer the patient to the hospital eye service or to an optometrist who has access to the drugs available on the Level 2 exemption list, where atropine is found.

On instillation

Care should be taken to minimise distress to the patient. Some practitioners administer a local anaesthetic, usually proxymetacaine 0.5 per cent, immediately before the cycloplegic agent. Anaesthetising the cornea has been shown to reduce discomfort as the subsequent drops are instilled18 and the local anaesthetic can facilitate absorption of the cycloplegic agent. However, if the child objects to the first set of drops, the second set will be very hard to administer.
Patient discomfort may also be reduced if the cycloplegic agent is sprayed onto the gently closed upper eyelids. Ismail, Rouse et al.20 and Wong, Fan et al.20 both found this system clinically equivalent to using drops in achieving cycloplegia. It is interesting to note that the study by Wong, Fan et al. involved a population with darkly pigmented irides.

It can often be challenging to achieve adequate cycloplegia in patients with darkly pigmented irides, due to the binding effect of the cycloplegic agent to the melanin in the iris. It is often necessary to repeat the instillation of cyclopentolate drops in patients with dark irides if little effect is seen after the first 10 or 15 minutes. Mohan and Sharma suggest that the optimal dosage of cyclopentolate 1 per cent in patients with brown irides is two drops, instilled 10 minutes apart.21

It should be remembered that occlusion of the puncta helps to minimise systemic absorption.

After instillation
The patient should be monitored to ensure maximum cycloplegia has occurred before retinoscopy commences. With older children and adults, measurements of the amplitude of accommodation can be made. With younger children and infants, dynamic retinoscopy can be used. Once a stable point is reached in the reduction of accommodation or the increase of the dynamic lag, it can be assumed that maximum cycloplegia exists.

A check to ensure that the drops reached the cornea can be made by assessing pupil size and response to direct light. Manny, Fern et al.22 confirmed that the time course for pupil dilation is not the same as that for cycloplegia. However, post instillation anisocoria can be a useful indicator of potential unequal cycloplegia.

In this study the time at which maximum cycloplegia was reached was also reassessed. Individuals with dark irides reached maximum cycloplegia, following use of 1 per cent cyclopentolate, after 30-40 minutes. However, it was discovered that the same level of residual accommodation was found in those with light irides a mere 10 minutes after instillation. The author has also found anecdotally that maximum cycloplegia in individuals with light irides can occur before maximum pupil dilation is reached.

Cycloplegic retinoscopy results are traditionally recorded in red. If atropine has been used, a tonus allowance of -1.00DS should be made.

Post cycloplegic check
Reviewing the patient two or three days after the cycloplegic refraction has taken place is useful to ascertain how much of the latent prescription he/she will tolerate.

Arguments against cycloplegia
The use of any drug on any patient has potential side-effects. Muscarinic antagonists are capable of producing not only local allergic reactions but also more widespread adverse reactions. Atropine is particularly well known for its potential to produce an adverse reaction, especially if ingested.13 There are also reports of CNS effects following the use of cyclopentolate23,24 and an account of an anaphylactic reaction to this drug has been given.25 Bagheri, Givard et al caution that side-effects are less frequent using one drop of cyclopentolate, compared to two or three drops.26

Another disadvantage to using cycloplegic agents is the time involved. It is not ideal to keep patients (particularly young ones) waiting for maximum cycloplegia to occur. Indeed, it has been demonstrated that a prolonged waiting time contributes to the distress experienced by children in a paediatric eye care setting.27 Due to the extended period of cycloplegia which occurs with the use atropine, there is a risk that a permanent squint could be established in a child with a large heterophoria or intermittent strabismus. In addition, children may decide that they no longer wish to cooperate with the practitioner after eye drops are instilled, and despite their use, an accurate result cannot be obtained.

Clearly, it may be sensible to have other techniques available to control accommodation.

Alternative methods for controlling accommodation

Fogging technique
In some individuals, fogging, by adding positive spheres (typically +0.75DS) to the manifest refraction, will relax the accommodation enough to give satisfactory results. After binocular balancing, and taking care not to stimulate the accommodation, the extra plus power is reduced in 0.25DS steps. At each step, the practitioner checks the patient’s visual acuity and should only maintain the reduction of the extra plus power if there is a genuine improvement in acuity. The endpoint is the maximum plus (or minimum minus) power that gives the maximum acuity.

Obviously this technique is only suitable for patients who have adequate communication skills and in whom visual acuity checks are fairly straightforward.

Mohindra technique
This adaptation to near fixation retinoscopy was developed by Mohindra in the 1970s.28 Mohindra promoted this technique as an alternative to cycloplegic retinoscopy, particularly useful in infants. It assumes that, in a completely darkened room, the eye will assume its resting accommodative level and that the retinoscopy light will not stimulate accommodation. Owens, Mohindra et al.29 showed that this is fundamentally the case, with the eye assuming an intermediate focus corresponding to its ‘dark focus’. This is shown as a small amount of myopia.

Providing that both tonic accommodation and the ‘dark focus’ points of all patients are identical then this technique should prove a reliable one in controlling the accommodation. The author has indeed found anecdotally that using this technique on undergraduate students produces almost identical retinoscopy results to those found when cycloplegia is used. Mohindra and Molinari30 when examining 5-7 year-old children, and Borghi and Rouse31 who refracted children between the ages of 3.6 and 10 years, found a good correlation between the retinoscopic results of the two techniques.

However, Wesson, Mann et al.32 suggested that caution should be used if cycloplegic retinoscopy was to be substituted as the two sets of results, cycloplegic retinoscopy and near retinoscopy, for infants and children did not match well. Maino, Cibis et al.33 demonstrated that results from children with higher refractive errors...
also showed a poor correlation. One theory as to why this might be the case is that tonic accommodation may vary from individual to individual. It is thought that hypermetropes may have a greater amount of tonic accommodation than myopes. Allen and O’Leary found that myopes had a significantly lower level of tonic accommodation when measured by pinhole technique than non-myopes. Therefore, it might be concluded that performing the Mohindra technique on higher hypermetropes may give an underestimation of the refractive error.

Twelker and Mutti also pointed out that the Mohindra technique takes time and practice to perform reliably. They recommended that cycloplegic retinoscopy be used by practitioners who perform a limited number of paediatric examinations.

Suggestions to modify Mohindra’s correction factor of 1.25DS have been made by Saunders and Westall. They believe that using a correction factor of 1.00DS for children over the age of two and 0.75DS for those under this age give results closer to those found under cycloplegia.

An argument exists for not worrying about any potential slight underestimation of hypermetropia. Because cycloplegic refraction results are often modified or ‘cut’ before prescribing, it is thought that results from the Mohindra technique would be close to what might actually be prescribed.

**Autorefractors and photorefraction**

Various studies have been made to determine whether autorefration and photorefraction without cycloplegia are adequate in controlling children’s accommodation to produce results comparable to those obtained with cycloplegia.

Barry and Konig concluded that use of the Nikon Retinomax monocular autorefractor, with a close working distance, could not be recommended for non-cycloplegic screening for refractive amblyopia in three-year-olds. Wesemann and Dick found that, with the same instrument, 24 per cent of children aged 2-12 years were over-minused when cycloplegia was not induced. However, Buchner, Schnorbus et al. found similar results when comparing those from the Welch Allyn SureSight hand-held autorefractor (Figure 2) on non-cyclopeged eyes to those obtained by cycloplegic refraction. Shryakumar and Bobier intimated that autorefractor designs that incorporated large working distances and distant fixation targets showed the least underestimation of hyperopia when used without cycloplegia. This would suggest that potential instrument myopia and proximal accommodation could be managed reasonably satisfactorily in this type of design. However, Choong and Goh concluded that the Grand Seiko WR5100K, which does allow distance target viewing, over minus prescriptions in 7-12 year old children without the use of cycloplegia.

When considering photorefraction, opinion is again divided. Anker, Atkinson et al. established that a non-cycloplegic videorefractive procedure, using the Clement Clarke isotropic videorefractor VPR-1, combined with orthoptic examination, was successful in detecting a large proportion of infants with significant refractive error, indicating that active accommodation was not a problem in this method. Blade and Candy ascertained that the PowerRefractor was also capable of detecting large amounts of defocus. Conversely, William, Lumb et al. found that the Topcon PR2000 photorefractor underestimated hypermetropic refractive errors in children under the age of eight, suggesting that accommodation was not well controlled with this instrument.

**Conclusion**

Investigators are divided as to how satisfactorily accommodation is controlled with autorefractors and photorefraction, and opinions vary as to the reliability of the Mohindra technique. There are also definite disadvantages to the use of cycloplegic agents. However, it would seem prudent for practitioners to be comfortable with the use of cycloplegics and to have some knowledge of the Mohindra technique to enable them to achieve adequate control of accommodation on the maximum number of patients.

Further research on levels of tonic accommodation in young children, particularly hypermetropes, may identify the need for a correction factor to be employed when using either Mohindra retinoscopy or photo/autorefraction. This may foster increased confidence in results obtained from these techniques.

**References**

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