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Convergence excess accommodative esotropia: a descriptive review of patients presenting over a period of 10 years

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Abstract

Aim: **Convergence excess accommodative esotropia describes an esotropia on accommodation at near fixation that is controlled to an esophoria/orthophoria at distance fixation with binocular single vision. Sixty-four cases have presented to the Leeds Teaching Hospitals NHS Trust over the last 10 years. This descriptive paper outlines the clinical characteristics of this cohort of patients.**

Methods: **Information was reviewed regarding all children diagnosed as having convergence excess accommodative esotropia entered onto a departmental database between 1999 and 2009.**

Results: **Only 3 children complained of diplopia at presentation. The mean refractive error of the group was right +2.90DS and left +2.80DS. The median angle of deviation was 25$^{\Delta}$BO at 1/3 m and 4$^{\Delta}$BO at 6 m. The mean Ac/A ratio using the gradient method was 6:1 at 1/3 m and 10:1 at 6 m. The angle of deviation was found to be altered by a period of monocular occlusion and prism adaptation. Twenty per cent of children required occlusion for amblyopia. Nine per cent of those with convergence excess were found to decompensate to constant esotropia with time.**

Conclusions: **Testing distance, a period of monocular occlusion and prism adaptation have been shown to alter the angle of deviation and the Ac/A ratio in convergence excess accommodative esotropia. Similarities between convergence excess and fully accommodative esotropia are outlined.**

Key words: Accommodative convergence to accommodation (Ac/A) ratio, Convergence excess esotropia

Introduction

The term 'convergence excess esotropia' defines an esotropia that is greater at near fixation than distance and was first described by Donders in 1864.[1,2] Much confusion has been generated by the term through the years. For some, it simply defines a constant esotropia greater at near than distance with no evidence of binocular single vision.[3] Others use it to define an esotropia at near fixation with orthotropia at distance that can be further categorised into accommodative, non-accommodative and hypo-accommodative convergence excess.[4,5] This study examines those with convergence excess accommodative esotropia – esotropia on accommodation at near fixation that is controlled to an esophoria/orthophoria at distance fixation with binocular single vision (BSV) and a high Ac/A ratio.[1] Convergence excess esotropia is differentiated from near esotropia by examining the effect of +3.00DS lenses on the near angle of deviation. In near esotropia the near angle will remain unchanged through the additional lenses, whereas in convergence excess esotropia the near angle will be significantly reduced – invariably resulting in binocular single vision at near.

Following previous investigation by the author into the influence of testing distance on the Ac/A ratio in fully accommodative esotropia[6] where the testing distance was found to affect the results, it was decided to routinely assess the Ac/A ratio at 1/3 m and 6 m in children with convergence excess esotropia to investigate whether similar changes occurred in this cohort. As the Ac/A ratio is frequently altered by a period of monocular occlusion in intermittent exotropia,[7,8] it was also decided to investigate the influence of occlusion on the Ac/A ratio for this cohort of patients.

Previous departmental audit revealed poor surgical success in cases of convergence excess esotropia, with approximately one-third of patients remaining esotropic post-operatively, one-third being successfully aligned and the remaining third becoming consecutively exotropic. It was thought that the variable surgical outcome may be a result of not revealing the true angle of deviation pre-operatively; therefore prism adaptation was undertaken in those wishing to consider squint surgery in an attempt to reveal the true angle of deviation and improve surgical results. Also, during scrutiny of the records of patients who had decompensated from convergence excess esotropia to constant esotropia the author observed a marked change in the distance angle of deviation with time without extra-ocular muscle weakness. It was postulated that this represented an uncovering or decompensation of the true distance angle of deviation due to changing fusional ability rather than an actual change in muscle balance. This would also be investigated with prism adaptation.

Sixty-four patients with accommodative convergence excess esotropia have presented to Leeds Teaching Hospitals NHS Trust over the last 10 years. This descriptive paper will outline the presentation, characteristics, treatment and outcomes of those children presenting with convergence excess in Leeds.

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Methods

Details of all children attending Leeds Teaching Hospitals with a diagnosis of convergence excess esotropia were prospectively entered onto a departmental database at the point at which the diagnosis was made. Differential diagnosis between near esotropia and convergence excess was made before entering the patient onto the database. This may have been at the first visit following refractive correction or at any point during the child's subsequent attendance, for example at a change in diagnosis. The database is updated at each clinic appointment. All orthoptic investigations entered onto the database were achieved by a standardised testing protocol and were performed in the vast majority of cases by the author, with a small amount of data being provided by two other very experienced examiners. All data used for measuring the Ac/A ratio were performed by the author using a strict testing protocol.

Sixty-four children (35 female, 29 male) attending with convergence excess esotropia were identified from the database and the following information was gathered: age at presentation, signs/symptoms at presentation, duration of signs/symptoms, refractive error and initial diagnosis after correction of refractive error, angles of deviation, strength of BSV, change in diagnosis, etc. The angle of deviation was measured using the prism and cover test at 1/3 m and 6 m and the presence of microtropia and necessity for occlusion was examined. The Ac/A ratio was measured using the gradient method at 1/3 m and 6 m. Treatment prescribed and binocular outcomes were collated. All children included in this study had undergone cycloplegic refraction, full refractive correction was issued in all cases and any spectacles issued were worn full time.

Results

Age at presentation

The mean age at presentation was 3 years 11 months (median 4 years, range 1 year 1 month to 9 years 1 month). The mean duration of signs/symptoms prior to presentation was 8.5 months (median 6 months, range 3 weeks to 48 months).

Signs and symptoms at presentation

Fourteen patients did not have a record of presenting signs in the hospital notes (3 of whom had been referred from other hospitals). Of the remaining 50 patients, 38 had a history of intermittent esotropia and 12 patients had a history of constant esotropia. Only 3 children volunteered symptoms of diplopia at presentation.

Initial diagnosis

Of the 64 children who, after refractive correction, subsequently met the criteria for convergence excess accommodative esotropia at presentation (before refractive correction) the provisional working diagnosis was:

Convergence excess esotropia: 22 (34%)
Constant esotropia: 18 (28%)
Non-specific intermittent esotropia/decompensating esophoria: 16 (25%)
Esophoria: 1 (2%)
No squint detected: 1 (2%)
Esotropic at near but distance cover test was not possible: 1 (2%)
Information not available: 5 (8%)

Refractive error

Sixty-one (95%) children were issued spectacles for full-time wear. The full prescription was issued in all cases. Hypermetropia $\geqslant +1.00$DS was corrected due to the esotropia. Correction of myopia and astigmatism was issued related to visual acuity. The mean spherical equivalent following cycloplegic refraction was: right $+2.90$DS (median $+2.50$ range -0.25 to $+7.50$), left $+2.80$DS (median $+2.50$, range -0.25 to $+7.00$).

Diagnosis after refractive correction

Two months after refractive correction/adaptation the diagnoses were:

Convergence excess esotropia: 36 (56%)
Fully accommodative esotropia: 13 (20%)
Constant esotropia: 9 (14%)
Non-specific intermittent esotropia: 1 (2%)
Too young for distance assessment: 1 (2%)
No abnormality detected: 1 (2%)
Information unavailable: 3 (5%)

All these patients subsequently met the criteria of convergence excess esotropia following a further period of time. Details are given in the section 'Progression of esotropia'.

Angle of deviation

Full refractive correction was worn and an alternate prism and cover test was performed whilst the child named pictures or letters of the smallest size discernible to each eye (Fig. 1). The median angle of deviation at 1/3 m was 25^{Δ}BO (SD 12^{Δ}, range 12^{Δ} to 65^{Δ}). The median deviation at 6 m was 6^{Δ}BO (SD 5.5^{Δ}, range 0^{Δ} to 20^{Δ}).

Ac/A ratio

The Ac/A ratio was measured using the gradient method in 57 patients at 1/3 m and at the same visit in 48 children at 6 m. The full refractive correction was worn. In an attempt to control accommodation the child was asked to name pictures or letters of the minimum size viewable by each eye whilst the measurements were undertaken with and without the ± 3.00DS lenses. If the ± 3DS lenses were not cleared with each eye, the patient was excluded from the results. After sufficient time, encouragement and explanation, all those tested were able to clear the $+3.00$DS lenses at 1/3 m. One child was not able to clear the -3.00DS lenses at 6 m. Details of those measured at 1/3 m and 6 m are found in Fig. 2. At 1/3 m the mean Ac/A ratio was 6:1 (SD 3:1, range -1.7:1 to 13.3:1). At 6 m the mean Ac/A ratio was 10:1 (SD 3.7:1, range 2:1 to 17.7:1). The mean difference in

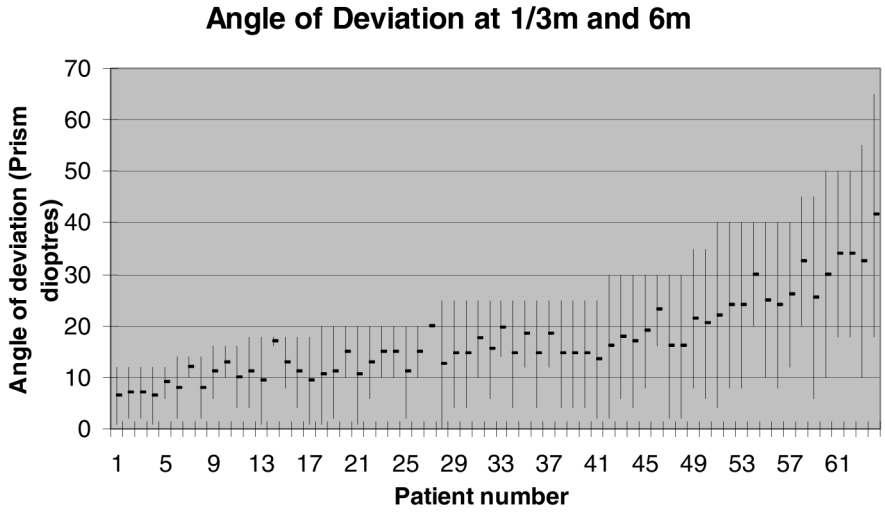

Fig. 1. Cases sorted by near angle of deviation. Top of bar represents near angle of deviation, bottom of bar represents distance angle of deviation (prior to prism adaptation).

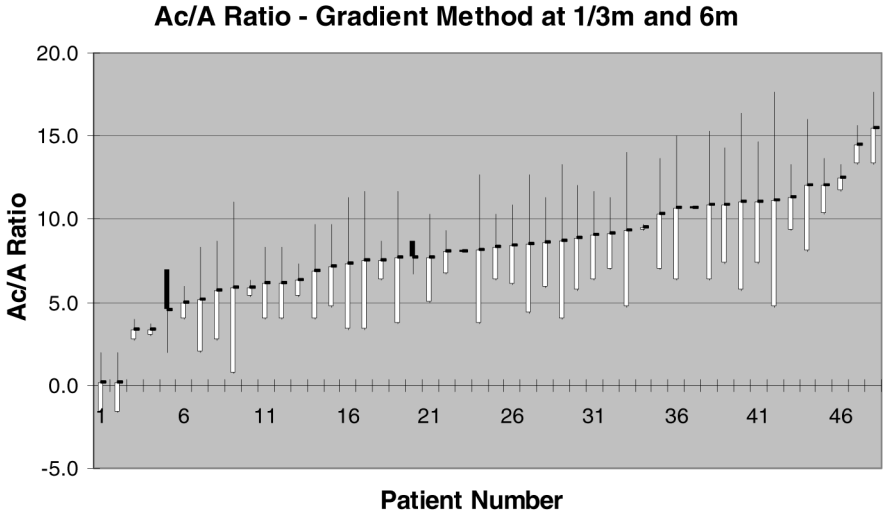

Fig. 2. Cases sorted by mean Ac/A ratio. The mean is denoted by the dot ([ratio 1/3 m + ratio 6 m]/2). For all patients except numbers 5 and 20 (black filled bars), the top of the bar represents the Ac/A ratio at 6 m and the bottom of the bar represents the Ac/A ratio at 1/3 m. Patients 5 and 20 had a near Ac/A ratio that exceeded the distance Ac/A ratio, therefore the top of the bar denotes the near ratio and the bottom of the bar the distance ratio.

the Ac/A ratio subtracting the 1/3 m from 6 m results was 4.9:1 (SD 3.6). The Ac/A ratio was significantly greater at 6 m than at 1/3 m (paired *t*–test, $p < 0.001$, 95% CI 3.89 to 5.97).

Ac/A ratio following occlusion

Ten children underwent re-measurement of the deviation following a 30 m in period of monocular occlusion as part of a previously reported study.[6] Following occlusion there was a change in the angle of deviation at 1/3 m of between -5^{Δ} and $+25^{\Delta}$. At 6 m the change ranged from -12^{Δ} to $+21^{\Delta}$. Following occlusion, a change in the Ac/A ratio of 2:1 or more was found in 7 patients at 1/3 m with 2 of these demonstrating a change of more than 4:1. Similarly, 6 of the 10 cases changed by 2:1 or more at 6 m with 2 of them changing by more than 4:1. Whilst these changes do not reach statistical significance (change in near Ac/A ratio: paired *t*-test, $p = 0.557$, 95% CI -11.8 to 6.8; change in distance Ac/A ratio: paired *t*-test, $p = 0.200$, 95% CI -11.8 to 2.8), there is a clear clinical significance in many of the cases.

Prism adaptation

Prism adaptation (PAT) was undertaken in 21 patients considering squint surgery. Criteria for consideration for surgery were the inability to control the deviation following treatment with bifocals or orthoptic exercises, or parental choice to discontinue bifocal wear. The near angle of deviation was fully corrected with Fresnel prisms that were split equally between the two eyes and the patient was reviewed 1 or 2 weeks later. The mean age at time of PAT was 7.2 years (range 4.42–9.25 years). Each patient tolerated the prisms well. The mean change in angle of deviation at 1/3 m following PAT

was 18.5$^{\Delta}$ (SD 12.1$^{\Delta}$, range -10^{Δ} to $+35^{\Delta}$) This was statistically significant (paired *t*-test, $p < 0.001$, 95% CI 15$^{\Delta}$ to 26$^{\Delta}$). At 6 m the mean change in deviation was 17.5$^{\Delta}$ (SD 10.9$^{\Delta}$, range -2^{Δ} to $+36^{\Delta}$). Again this was statistically significant ($p < 0.001$, 95% CI 16$^{\Delta}$ to 27$^{\Delta}$).

Bifocals

Thirty-seven patients were issued bifocal spectacles as a primary treatment; 4 additional children were issued bifocals post-operatively. The minimum additional plus lens that produces esophoria with reasonable fusion and stereopsis is prescribed initially. The mean age at issuing bifocals as a primary treatment was 63 months (SD 17 months, range 23 to 109 months). The mean length of time wearing bifocals was 32 months (SD 29, range 3 to 113 months). Some of these children are still wearing bifocals so the length of wear data are not complete. Six of the 37 children appeared to be successfully weaned from the bifocals; however, 3 of these children decompensated between 6 and 8 months later and required further intervention. Two children were discharged wearing bifocals. Nineteen of the 37 children treated initially with bifocals went on to have (or be listed for) surgery once it was shown that it was not possible to reduce the bifocal addition further without inducing a manifest deviation at near.

Microtropia

Nine (14%) children had a microtropia confirmed by fixation examination. Of these, only 4 had anisometropia of 1.25DS or more. Seven further children had suspected microtropia (evidenced by 4$^{\Delta}$ prism test) but not confirmed by fixation examination.

Occlusion

Thirteen (20%) of the 64 were prescribed occlusion therapy for amblyopia. Six of these had a confirmed associated microtropia, 4 had a suspected microtropia and the remaining children had normal central fixation.

Progression of esotropia

The 13 children initially diagnosed with fully accommodative esotropia following refractive correction controlled the deviation at near whilst wearing the spectacles for a mean period of 20 months before a manifest deviation at 1/3 m was first seen (median 16, SD 11, range 2 to 35 months). The mean spherical equivalent refractive error for this group was +3.60DS (range +1.00DS to +7.00DS). The median age at decompensation from fully accommodative esotropia to convergence excess accommodative esotropia was 58 months (mean 59, SD 11, range 39–75 months).

Six (9.8%) children spontaneously decompensated from convergence excess esotropia to a constant esotropia. Of these 6, following initial refractive correction, 3 had convergence excess accommodative esotropia immediately, 1 had remaining constant esotropia for 2 months before settling to convergence excess accommodative esotropia and 2 children had controlled to a fully accommodative esotropia for 14 and 15 months before losing control of the deviation at near. The angle of deviation at 6 m was seen to change considerably over this time. Details are given in Table 1. Four of these 6 children complained of diplopia at 6 m when manifest.

Surgery

Twenty-eight children have undergone squint surgery during the 10 years of data collection. Twenty underwent bilateral medial rectus (MR) recessions, 1 of whom also had bilateral inferior oblique myectomies. Five had single MR recession, 2 underwent unilateral MR recession with lateral rectus resection and 1 had a Faden posterior fixation suture to one MR. Since mid-2007, all children ($n = 17$) undergoing squint surgery have undergone pre-operative prism adaptation.

Discussion

The characteristics of convergence excess accommodative esotropia are described in Ansons and Davis' book *Diagnosis and Management of Ocular Motility Disorders*.[1] The age at presentation and degree of refractive error found in the present study relate well to those quoted. Ansons and Davis state that the Ac/A ratio 'often exceeds 8:1'. In this study 14 (25%) of the 57 children tested at 1/3 m had an Ac/A ratio of at least 8:1 as did 36 (75%) of the 48 tested at 6 m.

Ansons and Davis state that presentation of convergence excess accommodative esotropia is usually between 2 and 5 years of age. This study found the age of presentation to be between 2 and 9 years. The anecdotal clinical impression is that accommodative esotropia will tend to manifest itself when the child begins to really exert accommodation when becoming interested in fine detail. One would expect accommodative effort to be truly exercised when the child starts school at the age of 5 years; therefore an upper age for presentation of this degree would be expected. However, the intermittent nature of this type of strabismus and the lack of diplopia means that the age at presentation will be dependent not only on the observations of family and teachers – the deviation may have been present for some

Table 1. Change to 6 m angle of deviation following spontaneous decompensation to constant esotropia

Patient no.	Age at decompensation (years)	Time after presentation (months)	Diplopia	6 m pre-decompensation angle (prism dioptres)	6 m post-decompensation angle (prism dioptres)
1	6.75	13	No	6	30
2	7.25	33	Yes	4	25
3	8.3	62	Yes	10	30
4	8.9	26	Yes	4	16
5	5.3	27	No	6	20
6	7.3	76	Yes	6	16

time before being noticed – but also their motivation to seek a medical opinion. Of course it is also feasible that the deviation in these older children actually manifested itself at an older age.

This paper has outlined the progression of convergence excess esotropia. Some of the patients included in this study initially behaved as fully accommodative esotropes for some time before their vision broke down at near to convergence excess esotropia. Interestingly, the mean age that this decompensation generally occurred was around the age when children start school in the UK. A small number of these children with convergence excess esotropia then further decompensated to become constant esotropes. This occurred at a slightly older age, with the youngest being just over 5 years of age and the oldest being nearly 9. The decompensation of accommodative esotropia has been documented by others. Vivian[5] reported an increase in the near deviation in patients presenting initially with fully accommodative esotropia in 6–11% of cases and Dickie and Scott[9] reported that 13% of 114 patients with fully accommodative esotropia deteriorated to lose binocularity despite good compliance with spectacle wear. They found that the decompensation occurred at a mean age of 7.6 years (range 3.8 to 13.3 years) and was not related to Ac/A ratio. The age at decompensation was therefore slightly older in their study than in this present study. Dickie and Scott's study described the decompensation as 'total', i.e. the child decompensated at 1/3 m and 6 m not to a convergence excess esotropia. However, Dickie and Scott, in this American study, also state that 'almost all of the patients had at least peripheral fusion' prior to decompensation. This would imply that not all of their included patients would be categorised as true fully accommodative esotropes in the UK.

Havertape *et al.*[10] compared different methods of measuring the Ac/A ratio in accommodative esotropia and found that using −3.00DS lenses at 6 m fixation revealed a higher Ac/A ratio than using +3.00DS lenses at 1/3 m. Gage[11] examined the Ac/A ratio using the gradient method at 1/3 m and 6 m in a small group of esophoric and exophoric subjects and found that there was no statistical difference in outcome using the two methods in esophoria (although 2 subjects showed a change of 9:1 and 10:1 which would certainly be considered clinically significant); she also found that those with exophoria had a slightly reduced Ac/A ratio on distance fixation. A study by this author of the Ac/A ratio in fully accommodative esotropia[6] found that the testing distance did not influence the Ac/A ratio in a control group of subjects with small, well-compensated heterophoria (mean 2.2:1 at 1/3 m and 2.9:1 at 6 m), but in those with fully accommodative esotropia the Ac/A ratio was significantly larger when measured at 6 m (mean 9:1) than when measured at 1/3 m (mean 4:1). This present study similarly demonstrates the significance of testing distance when measuring the Ac/A ratio in convergence excess esotropia: the measure of the Ac/A ratio at 6 m exceeded the near ratio in 39 (81%) of 48 cases. Therefore it would appear that the testing distance used for measuring the Ac/A ratio has little influence on the results in small heterophoria but that in accommodative esotropia, both fully accommodative and convergence excess, the distance gradient method reveals a significantly larger result than the near method. It is feasible that the effort to accommodate through concave lenses at 6 m fixation results in a different (and perhaps more accurate) accommodative response from that when asking a patient to relax their accommodation through convex lenses at 1/3 m.

The effect of target size on the angle of deviation at 1/3 m and 6 m was also outlined in this author's fully accommodative esotropia study.[6] The paper compared the angle of deviation at 1/3 m and 6 m measured with the patient viewing a 6/60 and 6/6 target and, perhaps not surprisingly, demonstrated that the angle of deviation increased when viewing a 6/6 target compared with a 6/60 target in fully accommodative esotropia.

All the papers mentioned have measured the stimulus Ac/A ratio. It cannot be assumed that viewing a detailed target through plus and minus lenses will elicit an accommodative response exactly equal to the strength of the lens used. Dynamic retinoscopy would reveal the accuracy of accommodation in these children but few UK orthoptists currently have the skills to undertake this procedure. (Three children included in this study underwent dynamic retinoscopy with the hospital optometrist and showed accurate accommodative responses to a detailed target at 1/3 m. However, due to the small numbers tested, details are not included in the results.) Instructing the patient to read small letters whilst measurements are undertaken attempts to ensure that accurate accommodative change occurs in the clinical environment.

The usefulness of the stimulus Ac/A ratio as a diagnostic tool and its use in surgical planning should perhaps be re-considered. Many papers have outlined the differences in stimulus and response ratios[12–14] and this paper has outlined changes to the angle of deviation resulting from differing target size, fixation distance, prism adaptation and occlusion. These effects will affect the Ac/A ratio results. The number of factors influencing the measure of the Ac/A ratio means that the results will vary considerably depending on the testing regime adopted. Unless strict protocols in testing regimes are undertaken, the results are likely to be so variable as to render them of little diagnostic value. The size of the deviation following prism adaptation (or to a lesser extent following a period of monocular occlusion) is likely to be of more value when planning management of convergence excess esotropia than the actual Ac/A ratio. It is no longer routine practice to measure the Ac/A ratio in convergence excess within the department in Leeds.

This paper has demonstrated the close relationship between convergence excess and fully accommodative esotropia. The mean refractive error in this author's fully accommodative esotropia study[6] was +4.30DS (range +2.00DS to +8.00DS); the mean refractive error within this present study of convergence excess esotropia was +2.90DS (range −0.25 to +7.50). The Ac/A ratio is often high in both categories of strabismus. The fully accommodative esotropia study[6] split the subjects into two groups: those who learnt to control the deviation without the spectacles with time and those who did not. The study found that the group with fully accommoda-

tive esotropia who did not learn to control the deviation without spectacles had mean Ac/A ratios of 2.6:1 at 1/3 m and 9:1 at 6 m. This study of convergence excess accommodative esotropia found a higher mean Ac/A of 6:1 at 1/3 m but a similar Ac/A of 10:1 at 6 m. A proportion of children with fully accommodative esotropia are seen to decompensate to convergence excess over time, further linking these two conditions. It is proposed that convergence excess esotropia and fully accommodative esotropia are not truly distinct entities but represent different points on a spectrum of the same condition.

Horwood[15] has described the various drivers to accurate vergence (blur, accommodation, proximity, disparity) and has reported that disparity is the main driver for accurate vergence in most non-squinting individuals. Perhaps these main drivers are different in the sub-categories of intermittent strabismus? Maybe those hypermetropes who develop esotropia have vergence that is more driven by accommodation than those who remain fully binocular? Perhaps those who develop convergence excess esotropia have even more accommodative drive than those who develop fully accommodative esotropia? As yet we do not have knowledge of the drive to vergence in differing categories of strabismus.

Treatment of convergence excess esotropia with bifocals has produced limited success for the children in this cohort. Bifocals are routinely prescribed within the department as a first-line treatment. The minimum additional plus lens that produces esophoria with reasonable fusion and stereopsis is prescribed initially. The aim is to endeavour to reduce the addition by −0.50DS every 6 months (departmental guideline). If the deviation was not controlled with the reduced additional lens, the parents were given the option of increasing the addition again or considering surgery. It is the author's experience that reducing the bifocal addition down to +1.00DS is usually uncomplicated, but weaning the child from this small additional lens is often unsuccessful even with the addition of orthoptic exercises. Stewart and Scott[16] reported similar difficulties. Forty-three per cent of those with convergence excess wearing bifocals became 'bifocal failures' – the deviation increased beyond the patient's fusional capabilities during their bifocal treatment. Parents in Leeds are now counselled that bifocals are prescribed to maintain comfortable BSV until such time as accurate prism and cover test measurements are possible and prism adaptation can be undertaken. At this point surgery is planned.

Prism adaptation or a period of monocular occlusion may reveal a hidden large angle of deviation at 6 m in convergence excess accommodative esotropia that has been shown to decompensate to constant esotropia over time in a small group of patients. It is postulated that tenacious fusion masks the true distance angle of deviation in many patients with convergence excess in a similar way as described by Kushner[7] and Rosenfield *et al*.[8] in intermittent exotropia. The author's previous paper investigating convergence excess esotropia[17] suggested two subcategories of convergence excess accommodative esotropia:

- *True convergence excess*: Esotropia at 1/3 m with a small well-controlled esophoria at 6 m. No significant increase in the distance angle of deviation following a period of monocular occlusion or prism adaptation.
- *Simulated convergence excess*: The esophoria at 6 m increases significantly following occlusion or prism adaptation.

The paper postulated that sub-categorisation of this condition may influence its management. Those with true convergence excess may be at risk of consecutive distance exotropia following surgery and are possibly best managed with long-term bifocal use. Those with simulated convergence excess pose a low risk of consecutive exotropia and more aggressive surgery can be proposed. These patients may be at a greater risk of decompensating to constant esotropia over time.

Clinicians should be aware of the effect of fixation target size and the testing distance on the results of prism and cover test and consequently on the Ac/A ratio, and should consider a period of monocular occlusion or prism adaptation to reveal the true angle of deviation before planning surgical interventions.

References

1. Ansons AM, Davis H. *Diagnosis and Management of Ocular Motility Disorders*, 3rd edition. Oxford: Blackwell Science, 2001: chapt 12.
2. Donders FC. *On the Abnormalities of Accommodation and Refraction of the Eye.* London: The New Sydenham Society, 1864.
3. Wygnanski-Jaffe T, Trotter J, Watts P, Kraft S, Abdolell M. Preoperative prism adaptation in acquired esotropia with convergence excess. *J AAPOS* 2003; **7:** 28–33.
4. Arnoldi KA. Convergence excess: characteristics and treatment. *Am Orthopt J* 1999; **49:** 37–47.
5. Vivian AJ, Lyons CJ, Burke J. Controversy in the management of convergence excess esotropia. *Br J Ophthalmol* 2002; **86:** 923–929.
6. Garretty T. The Ac/A ratio as a predictor of control in fully accommodative esotropia. In: Pritchard C, Kholer M, Verlohr D, editors. *Orthoptics in Focus*. Transactions of the IX International Orthoptic Congress. Stockholm. Berufverband der Orthoptistinnen Deutschlands e.V., Nurenberg, 2000: 227–230.
7. Kushner BJ. Exotropic deviations: a functional classification and approach to treatment. *Am Orthopt J*; 1988; **38:** 81–93.
8. Rosenfield M, Rappon JM, Carrel MF. Vergence adaptation and the Ac/A ratio. *Ophthalmic Physiol Optics* 2000; **20:** 207–211.
9. Dickie CF, Scott WE. The deterioration of accommodative esotropia: frequency, characteristics, and predictive factors. *J Pediatr Ophthalmol Strabismus* 1988; **25:** 172–175.
10. Havertape SA, Cruz OA, Miyazaki EA. Comparison of methods for determining the Ac/A ratio in accommodative esotropia. *J Pediatr Ophthalmol Strabismus* 1999; **36:** 178–183.
11. Gage J. A comparison of the Ac/A ratio measurement using the gradient method at near and distance fixation. *Br Orthopt J*; 1996; **53:** 25–28.
12. Bhoola H, Bruce AS, Atchison DA. Validity of clinical measures of the Ac/A ratio. *Clin Exp Optom* 1995; **78:** 3–10.
13. Cooper J, Ciuffreda KJ, Kruger PB. Stimulus and response Ac/A ratios in intermittent expotropia of the divergence-excess type. *Br J Ophthalmol* 1982; **66:** 398–404.
14. Miyata M, Hasebe S, Ohtsuki H. Influence of accommodative lag upon the far gradient measurement of accommodative convergence to accommodation ratio in strabismic patients. *Jpn J Ophthalmol* 2006; **50:** 438–442.
15. Horwood A. The use of cues to convergence and accommodation in naïve uninstructed participants. *Vision Res* 2008; **48:** 1613–1624.
16. Stewart SA, Scott WE. Prognosis for accommodative esotropia treated with bifocals. *Am Orthopt J* 1993; **43:** 77–81.
17. Garretty T. Convergence excess esotropia: a proposed new classification and the effect of monocular occlusion on the Ac/A ratio. *J Pediatr Ophthalmol Strabismus* 2010; **47:** 307–312.