The Accommodative Element in Accommodative Esotropia

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• PURPOSE: To evaluate the effect of reducing the hyperopic correction on the state of binocular accommodative response in fully accommodative esotropia and to determine the "comfortable" amount of reduction in hyperopic correction.

• DESIGN: A cohort study.

• METHODS: Hyperopic corrections of children with a baseline refractive error of +1.50 to +5.0 diopters were gradually reduced in 0.50-diopter increments. Binocular accommodative ability was assessed by dynamic retinoscopy (monocular estimate method). Similar binocular accommodative responses were ascertained among patients with a baseline hyperopic correction of ≤3.0 of hyperopia and >3.0 of hyperopia, and patients were divided into two groups, group 1 (13 patients) and group 2 (18 patients), accordingly.

• RESULTS: After a reduction of 2.0 diopters in group 1 and 1.0 diopter in group 2, there was a decrease in accommodative response initially in the nondominant eye, accompanied by the dominant eye with a further reduction of 0.50 diopter. To overcome the bilateral accommodative lag, a reinstatement of a 0.50-diopter stronger hyperopic correction was required. Patients in group 1 tolerated a mean undercorrection of 2.37 diopters, and 77% were weaned from their spectacles. All of the children in group 2 were dependent upon spectacles at the completion of the study period. The final spectacle worn was a median of −1.67 diopters less than their full cycloplegic refraction.

• CONCLUSIONS: A complete binocular accommodative ability seems to be a prerequisite for the establishment of "comfortable" hyperopic undercorrections. It does not seem to be a reasonable approach to consider further reductions in hyperopic correction in the presence of a bilateral decreased accommodative performance. (Am J Ophthalmol 2006;141:819–826. © 2006 by Elsevier Inc. All rights reserved.)

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THE MAINSTAY OF TREATMENT IN ACCOMMODATIVE esotropia has been full optical correction of the hyperopic refractive error. This is perhaps the most successful means by which the esotropic deviation can be eliminated, thereby restoring sensory fusion in a majority of cases.

Hypermetropic infants have often not emmetropized before they show signs of strabismus,[1–3] and a reduction in the accommodative response has also been demonstrated in these children before a heterotropia was recognized.[1,4] Disturbances in the emmetropization process present before the onset of esotropia persist in children with strabismus. It has been shown that accommodative esotropes wearing their full hyperopic correction spectacles are less likely to go through emmetropization.[5–8] The mechanism of such impedance is problematic but could include a reduction in the need for accommodation, and accommodation in its turn might be involved in the reduction of hyperopia.

Many investigators have advocated gradually decreasing the hyperopic correction with stable refractive accommodative esotropia.[3,7–9] However, when an incremental reduction in spectacle power is attempted, also well documented is the observation that, while still remaining orthotropic, patients do not tolerate further reduction in their spectacle correction after a certain amount of decline has been accomplished. To our knowledge, there are no reports on the actual cause of this lack of success. In a recent study, Lambert and associates[10] reported that despite the possibility in accommodative esotropes of discontinuation of spectacle wearing as a result of increased fusional divergence amplitudes by gradual reduction of the hyperopic correction, only 22% of children with 3 diopters or more of hyperopia could be weaned from their spectacles.

We have assumed that if the deficiency in accommodation present before the onset of esotropia persisted after the development of squint, this could account for the intolerance to reduction of hyperopic correction. Therefore, the purposes of this article were to evaluate the effect of reducing the hyperopic correction on the state of accommodative response in the two eyes of patients with accommodative esotropia; to observe whether reduction of the hyperopic error would result in the expected stimulation of

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TABLE 1. Clinical Characteristics, Changes in Alignment, and Stereopsis at the Initiation and Completion of Incremental Hyperopic Reduction in Patients With Accommodative Esotropia and ≤3 Diopters Hyperopia (Group 1)

Patient No.	Age Esotropia Noted (y)	Age Spectacles Prescribed (y)	Age Weaning Initiated (y)	Initial Esotropia Distance/Near (PD)	Final Alignment Distance/Near (PD)	Initial Stereopsis (s/arc)	Final Stereopsis (s/arc)
1	4	5.5	8	0	0	240	240
				16 RET	6 RET		
2	4.5	4.5	8.5	14 LET	0	30	60
				25 LET	8 LET		
3	5	5	9	6 RET	0	60	30
				16 RET	0		
4	4.5	4.5	7.5	6 RET	0	120	120
				18 RET	4 RET		
5	5.5	5.5	8.5	0	0	120	240
				18 LET	4 LET		
6	3.5	4	7	16 LET	0	240	240
				18 LET	0		
7	5	5	9	20 RET	0	60	60
				20 RET	8 RET		
8	4.5	4.5	7.5	14 LET	0	30	60
				14 LET	6 LET		
9	5	5	8.5	0	0	60	60
				30 RET	8 RET		
10	3	4	8.5	18 LET	0	120	120
				25 LET	0		
11	4.5	6	9	14 RET	4 RET	240	60
				16 RET	6 RET		
12	5	5	8	25 RET	8 RET	30	60
				35 RET	8 RET		
13	4.5	4.5	7.5	18 RET	0	240	240
				20 RET	6 RET		

LET = left esotropia; PD = prism diopters; RET = right esotropia.

accommodation; and to determine the "comfortable" amount of reduction in hyperopic correction while still remaining orthotropic.

METHODS

THIS PROSPECTIVE STUDY INCLUDED PATIENTS WITH FULLY accommodative esotropia who had worn spectacles that incorporated their full cycloplegic refractive error and reduced the size of their esotropia to no more than 10 prism diopters on prism and alternate cover testing for two years or longer. All children included in the study had a cycloplegic refractive error between 1.50 and 5.0 diopters, at least 0.5 (Snellen chart) or better vision in each eye, a normal stimulus accommodation convergence/accommodation (AC/A) ratio (gradient method), and at least 240 seconds/arc stereopsis (TNO test) documented at their latest visit. Patients with a history of infantile esotropia, amblyopia (two lines or more of interocular difference in best-corrected visual acuity), and anisometropia (defined as the difference in the refractive error between the eyes of 2.0 diopters or greater of sphere or cylinder) were not included in the study. Accordingly, additional problems such as neurologic conditions, prematurity, or previous extraocular muscle surgery were other exclusion criteria. Approval of the study was obtained from the institutional review board, and informed consent was taken.

Full cycloplegic refraction was prescribed at the initial visit, and cycloplegic refractive checking was repeated at each follow-up visit. Refractive errors were ascertained using retinoscopy 30 to 45 minutes after the instillation of cyclopentolate 1% drops and verified using a hand-held autorefractometer (Nicon-Retinomax, Kanagawa, Japan).

Binocular accommodative ability was assessed by dynamic retinoscopy on all patients wearing spectacles incorporating full cycloplegic refractive error (that is, at the time of initiation of the study) and was repeated at each follow-up attendance with the current spectacle correction. The subject, wearing distance correction, was asked to fixate on a detailed near target (a small letter chart) placed close to the retinoscopic light source, with the retinoscope and target held approximately at the normal reading position. We concentrated on changes in the spherical refraction because eyes naturally focus on the least hyperopic meridian. For this reason, in most cases,

TABLE 2. Clinical Characteristics, Changes in Alignment, and Stereopsis at the Initiation and Completion of Incremental Hyperopic Reduction in Patients With Accommodative Esotropia and >3 Diopters Hyperopia (Group 2)

Patient No.	Age Esotropia Noted (y)	Age Spectacles Prescribed (y)	Age Weaning Initiated (y)	Initial Esotropia Distance/Near (PD)	Final Alignment Distance/Near (PD)	Initial Stereopsis (s/arc)	Final Stereopsis (s/arc)
1	1.5	2	7	30 RET	0	240	240
				35 RET	8 RET		
2	4.5	5.5	8.5	25 RET	0	240	240
				30 RET	0		
3	3.5	4	8	14 LET	6 LET	60	60
				18 LET	10 LET		
4	3	4.5	7.5	14 LET	0	120	120
				20 LET	0		
5	3.5	3.5	9	25 LET	6 LET	120	240
				30 LET	8 LET		
6	3	3	8.5	25 LET	0	120	120
				25 LET	0		
7	2	2.5	7.5	25 RET	8 RET	240	120
				25 RET	8 RET		
8	2	2	8	35 LET	0	60	30
				40 LET	8 LET		
9	3	3	8	14 RET	4 RET	30	120
				25 RET	8 RET		
10	3	3.5	8.5	16 RET	0	60	60
				20 RET	6 RET		
11	2.5	2.5	7	25 RET	0	60	60
				35 RET	0		
12	4.5	4.5	7.5	20 LET	0	30	120
				20 LET	0		
13	4	4	7	20 LET	0	240	120
				30 LET	0		
14	2	2	8	30 RET	0	120	240
				35 RET	6 RET		
15	4.5	4.5	7.5	25 RET	0	60	60
				25 RET	0		
16	3.5	3.5	8.5	35 LET	0	120	120
				40 LET	0		
17	1.5	2.5	7	35 RET	6 RET	240	240
				35 RET	6 RET		
18	3	3.5	8	14 LET	0	240	240
				20 LET	0		

LET = left esotropia; PD = prism diopters; RET = right esotropia.

the meridian of least hypermetropia was used, which was the horizontal in most subjects. If accommodation was accurate, then the reflex would be neutral. If the subject was underaccommodating in one or both eyes, that is, there was a lag of accommodation, then a "with" movement was seen and plus lenses were added until the movement of the near retinoscopic reflex was neutral (monocular estimate method, dynamic retinoscopy). Because falsely abnormal results could be obtained by inattentive or uncooperative patients, patients were strongly encouraged to attend to the near target and to maintain this level of accommodation for several seconds during testing. The result of dynamics retinoscopy was described as normal only if it was "rapid, complete, and steady."

It has been shown that children become less hyperopic or more myopic after 7 or 8 years of age.[11,12] Based on this information and to minimize the possibility of their losing stereopsis or binocular vision if their esotropia was to recur with undercorrection of hyperopia, the lowest age for participation was seven years.

The hyperopic correction was decreased in 0.50-diopter increments at follow-up visits in six-month intervals. The reduction was accomplished only if the patient was within 10 prism diopters of orthophoria at distance and near with his or her recent prescription and if dynamic retinoscopy revealed rapid, complete, and steady accommodation in at least one of the eyes. Decompensation was defined as a primary position distant esodeviation

TABLE 3. Changes in Refraction and Binocular Accommodative Responses During the Period of Incremental Hyperopic Reduction in Patients With ≤ 3 Diopters Hyperopia (Group 1)

Patient No.	Initial Refraction OD/OS (D)	Last Refraction OD/OS (D)	Last Prescription OD/OS (D)	Dynamic Retinoscopy Findings		
				+1.50 Decline	+2.0 Decline	+2.50 Decline
1	+2.0	+2.50	None	N/N	N/N	L/N
	+2.0	+2.50				
2	+2.50 (+0.50 × 90)	+1.50 (+0.50 × 90)	None	N/N	N/N	N/L
	+2.50 (+0.25 × 90)	+2.50 (+0.50 × 90)				
3	+1.75	+2.75	+ 0.75	N/N	L/N	L/L
	+2.0	+2.50	+ 0.50			
4	+1.50	+0.50	None	N/N	—	—
	+2.25	+1.0				
5	+2.0 (+0.50 × 60)	+2.50 (+0.50 × 60)	None	N/N	N/L	L/L*
	+2.0 (+0.50 × 120)	+2.50 (+0.50 × 120)				
6	+2.0	+2.0	None	N/N	N/N	N/N
	+2.50	+2.50				
7	+2.50	+2.50	None	N/N	N/N	L/N
	+2.25	+2.00				
8	+2.50	+2.50	None	N/N	N/N	L/N
	+1.50	+2.0				
9	+2.0 (+0.50 × 180)	+2.0 (+0.50 × 180)	None	N/N	L/N	—
	+2.0 (+0.50 × 180)	+2.0 (+0.50 × 180)				
10	+2.25 (+0.75 × 90)	+2.50 (+0.75 × 90)	+0.50 (+0.75 × 90)	N/N	N/L	L/L
	+2.25 (+0.50 × 90)	+2.50 (+0.50 × 90)	+0.50 (+0.50 × 90)			
11	+2.50	+2.50 (+0.50 × 90)	None	N/N	N/N	L/N
	+1.50 (+0.75 × 90)	+1.50 (+0.75 × 90)				
12	+2.50 (+1.0 × 60)	+2.0 (+1.0 × 60)	None	N/N	N/N	N/N
	+2.50	+2.50				
13	+2.50 (+0.50 × 90)	+2.0 (+0.50 × 90)	+0.50 × 90	N/N	L/N	L/L
	+1.75 (+1.0 × 90)	+2.0 (+1.0 × 90)	+1.0 × 90			

D = diopters; L = low (accommodative lag); N = normal (complete and steady accommodative response).
*Patients with no symptoms of asthenopia.

originally but no longer reduced to 10 prism diopters or fewer.

At each follow-up attendance, an assessment of compliance with the new prescription was made. Asthenopia was addressed by asking about symptoms associated with reading (studying or hobby reading) or performing other close work (for example, video games, hobbies), difficulty with near tasks (inability to concentrate or a loss of comprehension over time, ocular strain, blur, fatigue), headaches, and sensitivity to light.

At the completion of the study period, similar binocular accommodative responses were ascertained among patients with a baseline hyperopic correction of ≤3.0 of hyperopia and >3.0 of hyperopia. Based on these refractive ranges, patients were divided into two groups, group 1 and group 2, accordingly.

RESULTS

OF THE TWO GROUPS WITH INTRINSICALLY SIMILAR BINOCULAR accommodative responses, group 1 consisted of 13 and group 2 of 18 children accordingly (Tables 1 and 2). Before the initiation of undercorrection, assessment of binocular accommodative ability by dynamic retinoscopy revealed rapid, complete, and steady accommodative response in both eyes of all 31 children wearing spectacles incorporating full cycloplegic refractive error. During the interval of incremental reduction, it was apparent that the reduction of hyperopic correction brought about changes in accommodative performance. After a certain level of decline in the baseline hyperopic correction (2.0 diopters in group 1 and 1.0 diopter in group 2) was accomplished, there was decrease in accommodative response (lag of accommodation) for near targets (Tables 3 and 4). Assessment of binocular accommodative ability at this stage revealed an interocular difference of accommodative amplitudes between the two eyes (unequal effective accommodation). In the eyes with unilateral decreased accommodative response, retinoscopic neutrality was achieved with at least a 0.75-diopter lens, indicating that the patient was under-accommodating at least 0.75 diopter. The average plus add (monocular estimate method, dynamic retinoscopy) was

TABLE 4. Changes in Refraction and Binocular Accommodative Responses During the Period of Incremental Hyperopic Reduction in Patients With >3 Diopters Hyperopia (Group 2)

Case No.	Initial Refraction OD/OS (D)	Last Refraction OD/OS (D)	Last Prescription OD/OS (D)	Dynamic Retinoscopy Findings			
				+1.0 D Decline	+1.50 D Decline	+2.0 D Decline	+2.50 Decline
1	+5.0	+5.0	+4.0	L/N	L/L	—	—
	+4.0	+3.50 (+0.50 × 70)	+4.0 (+0.50 × 70)				
2	+3.50 (+1.0 × 90)	+3.50 (+1.0 × 90)	+1.50 (+1.0 × 90)	N/N	N/N	L/N	L/L
	+3.0 (+0.75 × 90)	+3.0 (+0.75 × 90)	+1.0 (+0.75 × 90)				
3	+3.0	+2.50 (+0.75 × 90)	(+0.75 × 90)	N/N	N/N	N/L	L/L*
	+3.0	+3.50 (+0.50 × 90)	+1.0 (+0.50 × 90)				
4	+3.0 (+1.0 × 90)	+3.0 (+1.0 × 90)	+1.50 (+1.0 × 90)	N/N	N/L	L/L	—
	+4.0	+4.50	+2.50				
5	+5.0	+5.0	+3.50	N/N	N/L	L/L	—
	+4.50 (+0.50 × 90)	+4.50 (+0.50 × 90)	+3.0 (+0.50 × 90)				
6	+3.0	+3.0 (+0.50 × 90)	+1.0 (+0.50 × 90)	N/N	N/N	N/L	L/L
	+3.50	+3.25	+1.25				
7	+4.50	+4.0 (+0.75 × 90)	+2.50 (+0.75 × 90)	N/N	L/N	L/L	—
	+5.0	+5.0	+3.50				
8	+4.0 (+0.50 × 90)	+4.0 (+0.50 × 90)	+2.0 (+0.50 × 90)	N/N	N/L	L/L*	—
	+4.50 (+0.50 × 90)	+4.50 (+0.50 × 90)	+2.50 (+0.50 × 90)				
9	+3.50	+3.50	+1.0	N/N	N/N	L/N	L/L*
	+3.25	+2.75	+0.25				
10	+4.0	+4.0	+2.0	N/N	N/N	L/N	L/L
	+3.50	+3.50	+1.50				
11	+4.50 (+0.50 × 120)	+4.0	+2.50	N/N	L/N	L/L	—
	+4.0 (+0.75 × 60)	+4.0 (+0.50 × 60)	+1.50 (+0.50 × 60)				
12	+3.0	+1.50	VP	N/N	N/L	L/L	—
	+3.50 (+0.50 × 180)	+3.0 (+0.50 × 180)	+1.0 (+0.50 × 180)				
13	+3.75	+3.50	+2.0	N/N	N/L	L/L	—
	+4.50 (+0.50 × 60)	+4.0 (+0.75 × 60)	+2.50 (+0.75 × 60)				
14	+5.0	+5.0	+4.0	L/N	L/L	—	—
	+4.25	+3.75	+2.75				
15	+4.50	+5.0	+4.0	L/N	L/L	—	—
	+4.0 (+0.50 × 100)	+3.50 (+0.50 × 100)	+2.50 (+0.50 × 100)				
16	+3.75 (+0.50 × 90)	+4.25 (+0.50 × 90)	+2.75 (+0.50 × 90)	N/N	N/L	L/L	—
	+4.25 (+0.50 × 90)	+3.50 (+0.75 × 90)	+2.0 (+0.75 × 90)				
17	+4.50	+3.0 (+1.25 × 80)	+1.50 (+1.25 × 80)	N/N	L/N	L/L	—
	+4.0	+2.50 (+1.0 × 100)	+1.0 (+1.0 × 100)				
18	+325 (+0.50 × 90)	+4.0 (+0.50 × 90)	+2.0 (+0.50 × 90)	N/N	N/N	N/L	L/L
	+3.50	+3.50 (+1.0 × 90)	+1.50 (+1.0 × 90)				

D = diopters; L = low (accommodative lag); N = normal (complete and steady accommodative response).
*Patients with no symptoms of asthenopia.

0.85 diopter (range 0.75 to 1.0 diopters) for group 1 and 0.98 diopter (range 0.75 to 1.25 diopters) for group 2.

Lag of accommodation was always documented initially in the nondominant eye and accompanied by the dominant eye with a further reduction of 0.50 diopter of the hyperopic correction, a common finding in both groups. Bilateral decreased accommodative response was not encountered as a primary sign of accommodative insufficiency in any of the children enrolled in the study group.

Concerning both groups, symptoms reported were those of asthenopia usually commencing after a period of near work and were strongly associated with the finding of bilateral accommodative insufficiency on dynamic retinoscopy. Patients with a unilateral decreased accommodative response did not present with any symptoms. To overcome the bilateral accommodative lag, reinstatement of a 0.50-diopter stronger hyperopic correction as a second event after the first reduction was required. Asthenopic complaints disappeared after the prescription of this correction, and the unilateral lag of accommodation present did not cause in any symptoms.

Of the 13 children with less than 3.0 diopters hyperopia (group 1), none had an accommodative lag until the incremental reduction of hyperopia reached 2.0 diopters

(Table 3). At this stage, five of 12 patients (42%) demonstrated an accommodative lag in the nondominant eye accompanied by the dominant eye with a further 0.50-diopter reduction of the hyperopic correction. When a total decline of 2.50 diopters was accomplished, only two (18%) of 11 patients had a bilateral complete and steady accommodative response. The remaining nine (82%) had an accommodative insufficiency in the nondominant eye (five patients, 56%) or both eyes (four patients, 44%). Three of the four patients with bilateral lag (that is, with the exception of case 5) had symptoms of asthenopia. To overcome the bilateral accommodative lag, reinstatement of a 0.50-diopter stronger hyperopic correction was required. The three patients continued to require spectacle corrections for near vision to relieve their asthenopic complaints. The unilateral lag of accommodation still present with these corrections did not cause any symptoms. The remaining 10 patients in this group were able to discontinue spectacle wear. By the end of the study period, patients in this group tolerated a mean undercorrection of their full cycloplegic refractive error of 2.37 diopters (range 2 to 2.50 diopters) while still remaining orthotropic.

Among the 18 patients with more than 3.0 diopters hyperopia (group 2), there had already been a unilateral accommodative lag in three (17%) when a reduction of 1.0 diopter of hyperopia was accomplished (Table 4). When a decline of 1.50 diopters was achieved, a bilateral accommodative response was bilaterally accurate only in six (33%). The remaining 12 (67%) had an accommodative insufficiency in the nondominant eye (nine patients, 50%) or both eyes (three patients, 17%). Among the 15 patients with a 2.0-diopter reduction of the baseline hyperopic correction, none revealed evidence of a full bilateral accommodation to a near stimulus viewing under binocular conditions. Of these patients, accommodation was insufficient unilaterally in six (40%) and bilaterally in nine (60%). Patients with a bilateral accommodative lag, with the exception of cases 3, 8, and 9, required reinstatement of a 0.50-diopter stronger hyperopic correction, that is, the prescription of the lens power in the previous examination, to overcome symptoms arising from accommodative insufficiency. A reduction of 2.50 diopters of the baseline hyperopic correction could not be accomplished in any except two of the children (cases 3 and 9) who did not have asthenopic symptoms associated with bilateral lag of accommodation.

All of the children in this group were dependent upon spectacles at the completion of the study period. The final spectacle worn was a median of -1.67 diopters (range 1.0 to 2.50 diopters) less than their full cycloplegic refraction.

Decompensation of a previously controlled deviation at any of the follow-up visits was not identified in any of the patients.

DISCUSSION

ACCOMMODATIVE RESPONSE OFTEN DIFFERS BETWEEN measurements under monocular and binocular conditions, and an interaction of both eyes on accommodation is strongly suggested as the cause.[13,14] Formal measurements of accommodative amplitudes offer no information on how well a patient can accommodate in real-life situations, provided that they must be performed monocularly, making it impossible to compare the accommodative state of the eyes simultaneously.[15,16] This missing information can be available with the use of dynamic retinoscopy technique. Dynamic retinoscopy allows rapid and accurate assessment of accommodative ability during binocular accommodation, as the examiner quickly switches back and forth between eyes.[17–20]

Investigation of the accommodative responses in the fully accommodative esotropic patients in this series revealed a constant reduction of the accommodative response documented initially in the nondominant eye, with the accompaniment of the dominant eye with a further 0.50-diopter reduction of the hyperopic correction. In infancy the eye is capable of 15 diopters of accommodation. From around five years of age, the accommodative amplitude progressively decreases at a rate of approximately 0.30 diopter per year.[21] Thus at the age of 7 years, it is approximately 13 diopters, that is: $15 - (0.3 \times 7)$ diopters).

To focus an object at a reading distance of 25 cm, the emmetropic eye must accommodate by 4 diopters. However, for comfortable near vision, one third of the available accommodation must be left in reserve. When a reduction of 2 diopters is accomplished, a child would still need 4 diopters of accommodation to see clearly at near and a reserve accommodation, which would be one third of his or her available accommodation, to have a comfortable near vision. When a hyperopic reduction of 2.50 diopters among group 1 and 1.50 diopters among group 2 was achieved, patients began to experience difficulty and discomfort for near vision associated with bilateral lag of accommodation.

The beginning of discomfort at this specific level apparently posits that: (1) it may happen due to the removal of the reserve accommodation for comfortable vision. If reserve accommodation is 2 to 2.50 diopters among patients with $\leq$3.0 spherical hypermetropia and 1 to 1.50 diopters among patients with $>$3.0 spherical hypermetropia, the total amount of available accommodation appears to be in the range of 6 to 6.50 diopters (that is, 4 diopters + [2 to 2.50 diopters]), and for the second group of patients, in the range of 5 to 5.50 diopters (that is, 4 diopters + [1 to 1.50 diopters]), respectively. (2) The incremental reduction of the hyperopic correction did not result in the expected stimulation of accommodation. The primary effect of glasses is to clear vision and control accommodative demand. If blurred vision were the principal stimulus for accommodation, a 0.50-diopter lag of accommodation should generate sufficient blur to provide a stimulus for innervation of the accommodative system,[21–23] but, in fact, it did not.

The reduction in the total amount of available accommodation and the disturbance in the stimulation of accommodation could explain why patients with accommodative esotropia fail to tolerate further reduction in their spectacle correction after a certain amount of decline has been accomplished.

Lambert and associates[10] provided empirical data supporting the claim of some investigators suggesting that by gradual reduction of the hyperopic correction, spectacles could be discontinued in children with less than 3 diopters of hyperopia. In their study, they were able to discontinue spectacles of 91% of children with fully accommodative esotropia if the refractive error was less than 3 diopters. A possible explanation is that although the total amount of available accommodation is reduced, bilateral lag of accommodation causing asthenopic symptoms does not appear to develop until an incremental reduction of 2.50 diopters is accomplished among most of these patients. Bilateral accommodative lag demonstrated among 82% at this level of decline does not adversely affect the discontinuation of glasses, because hyperopia is under 3 diopters.

Our data show the "comfortable" amount of incremental reduction in hyperopic correction achieved while still remaining orthotropic to be a median of 2.37 diopters (range 2 to 2.50 diopters) and −1.67 diopters (range 1.0 to 2.50 diopters) less than the full cycloplegic refraction among patients with ≤3 diopters hyperopia and >3 diopters hyperopia, respectively. Once it has been recognized that the amount is different among the two groups, the question that arises is what is the cause. Clinically, the amplitude of accommodation is measured from infinity to the nearest point of subjective clear vision with maximal accommodation expended, without compensation for the depth of focus. However, it should be measured from the far point to the near point, incorporating appropriate compensation for the depth of focus at both focal extremes and thus effectively reducing its inflated clinical estimate by 0.50 to 1.00 diopter in patients with normal vision. In patients with vision abnormalities such as amblyopia, depth of focus is greater because of neurosensory insensitivity, and therefore a larger compensation is warranted.[24] The question arises whether such neurosensory insensitivity exists in patients with >3 diopters hyperopia, which in that case could adversely affect the tolerance of greater hyperopic undercorrections.

This study needs to be viewed in light of the following limitations. We evaluated a very select group of patients with fully accommodative esotropia without amblyopia and at least 240 seconds/arc stereopsis. In addition, patients whose baseline refractive error exceeded 5.0 diopters were excluded. One cannot extrapolate results from this study with confidence to patients who have those criteria that were excluded. Although there is no reason to suspect that patients with other characteristics would behave differently, there are no data to verify the assumption. We are also aware that the number of patients included in the study is small. For this reason, whether our observations are applicable to all patients with fully accommodative esotropia may be subject to question.

Currently, a good binocular accommodative ability seems to be a prerequisite for the establishment of "comfortable" hyperopic undercorrections. On the basis of the data reported herein, the following recommendations seem appropriate: All patients subject to receive incremental hyperopic reductions in their spectacles should have their binocular accommodative ability clarified. Dynamic retinoscopy allows rapid and accurate confirmation of accommodative ability during binocular accommodation. If accommodation is complete, neutralization of the retinoscopic reflex is detected bilaterally with the current spectacle correction. If there is unilateral decreased accommodative response, a more thorough assessment by dynamic retinoscopy might possibly help identify before further reduction those patients who are destined to develop asthenopia, permitting appropriate forewarning or cessation of additional reduction. In view of aforementioned investigations, it does not seem to be a reasonable approach to consider further reductions in hyperopic correction in the presence of a bilateral decreased accommodative performance.

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Biosketch

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