

The Long-term Follow-up of Accommodative Esotropia in a Population-based Cohort of Children

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Purpose: To report refractive and surgical outcomes in a cohort of children with accommodative esotropia.

Design: Retrospective population-based cohort.

Participants: All pediatric patients (<19 years) diagnosed with accommodative esotropia in Olmsted County, Minnesota, from January 1, 1975, to December 31, 1994.

Methods: Medical records identified by the Rochester Epidemiology Project were reviewed for spectacle and surgical management.

Main Outcome Measures: Rate of surgical intervention and discontinuation of spectacles for esotropia.

Results: A total of 306 children with accommodative esotropia were diagnosed during the study years; 244 (80%) had fully accommodative esotropia (FAET) and 62 (20%) had partially accommodative esotropia (PAET). The Kaplan–Meier rate of discontinuing spectacles for strabismus in this population was 8% by 5 years after diagnosis, 20% by 10 years, and 37% by 20 years. Children born prematurely ($P = 0.046$) or with a greater initial hyperopic refractive error ($P < 0.001$) were significantly less likely to become spectacle-free during the follow-up period. During a median follow-up of 9.8 years (range, 0–27.9 years), 33 (13.5%) of the 244 subjects with FAET eventually underwent strabismus surgery. Male gender ($P = 0.039$) and an earlier age at onset ($P = 0.008$) and diagnosis ($P < 0.001$) of FAET were associated with a higher likelihood of requiring surgery.

Conclusions: The majority of children with accommodative esotropia in this population continued to require spectacle correction into their second decade of life. A small proportion of children with FAET required surgical intervention, which was more likely to occur among boys and in those with an earlier age at onset and diagnosis of their deviation.

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Accommodative esotropia is the most prevalent form of ocular misalignment among Western populations, comprising 28% of childhood strabismus and half of all esodeviations.^{1,2} The convergent deviation is the result of an abnormal activation of the accommodation reflex required to overcome the blur associated with uncorrected hypermetropia.³ Treatment typically consists of hypermetropic spectacle correction followed sometimes thereafter with surgery for those with a significant non-accommodative element, as in partially accommodative esotropia (PAET), or for those with fully accommodative esotropia (FAET) who subsequently deteriorate. The natural history of accommodative esotropia has been studied; however, none of the prior reports are population-based.^{4–10} This study describes the long-term outcomes of children diagnosed with accommodative esotropia as residents of Olmsted County, Minnesota, over a 20-year period.

Subjects and Methods

The medical records of all patients younger than 19 years of age who were residents of Olmsted County, Minnesota, when diagnosed with accommodative esotropia by an ophthalmologist between January 1, 1975, and December 31, 1994, were retrospec-

tively reviewed. Potential cases of esotropia were identified using the resources of the Rochester Epidemiology Project, a medical record linkage system designed to capture data on any patient–physician encounter in Olmsted County, Minnesota.¹¹ The racial distribution of Olmsted County residents in 1990 was Caucasian 95.7%, Asian American 3.0%, African American 0.7%, and Native American and other 0.3% each. The population of this county (106 470 in 1990) is relatively isolated from other urban areas, and virtually all medical care is provided to residents by the Mayo Clinic or the Olmsted Medical Group and their affiliated hospitals. Unaffiliated area optometrists rarely were the sole provider of eye care to children with strabismus during the study years of this investigation.

This study was approved by the institutional review boards of Mayo Clinic and Olmsted Medical Group. We initially identified the medical records of all patients aged 0 to 18 years who were diagnosed by an ophthalmologist as having any form of esotropia or unspecified strabismus from 1975 to 1994. All diagnoses were entered into the Rochester Epidemiology Project database by trained personnel who reviewed the entire medical record. The medical records of 2471 potential patients were reviewed for this study. Trained residency checkers verified patients' residency status at the time of birth and at diagnosis using information from city and county directories. Children not living in Olmsted County at the time of diagnosis were excluded, as were patients with an underlying or associated neurologic, paralytic, or ocular sensory

Table 1. Historical and Initial Clinical Characteristics of 306 Children Diagnosed with Accommodative Esotropia in Olmsted County from 1975 to 1994

	FAET+PAET	FAET	PAET	P Value
	N = 306	N = 244	N = 62	
Male gender	165/306 (54%)	127 (52%)	38 (61%)	0.20
Family history	92/218 (42%)	72/173 (41.6%)	20/45 (44.4%)	0.74
Prematurity	15/245 (6.1%)	11/192 (5.7%)	4/53 (7.6%)	0.75
Mean birth weight	3398 (1030–4880) (n = 250)	3418 (1030–4852) (n = 196)	3324 (1646–4880) (n = 54)	0.25
Mean age of onset in yrs (range)	3 (1 day to 12.5 yrs) (n = 193)	3.2 (1 day to 12.5 yrs) (n = 146)	2.5 (1 day to 5.6 yrs) (n = 47)	0.015
Mean age at diagnosis in yrs (range)	4.0 (2.2 mos to 18.6 yrs)	4.1 (2.2 mos to 18.6 yrs)	3.6 (4.6 mos to 14.5 yrs)	0.026
Amblyopia (%)	94/282 (33.3%)	72/223 (32.3%)	22/59 (37.3%)	0.53
Mean angle deviation in PD at distance (range)	19.1 (0–70)	17.3 (0–70)	26.0 (0–60)	<0.001
Mean angle deviation in PD at near (range)	25.3 (0–90)	23.3 (0–60)	33.3 (10–90)	<0.001
Inferior oblique dysfunction (%)	23/306 (7.5%)	19/244 (7.8%)	4/62 (6.5%)	1.00
Dissociated vertical deviation (%)	3/306 (1%)	2/244 (0.8%)	1/62 (1/6%)	0.49
Mean cycloplegic refraction (min, max)	+3.8 (–3 to +8.8)	+3.9 (–3 to +8.8)	+3.2 (+0.7 to +7.5)	0.002

FAET = fully accommodative esotropia; PAET = partially accommodative esotropia; PD = prism diopters. Categorical variables are reported using number (percent), and continuous variables are reported using mean (range).

disorder. All remaining patients with an esotropia of 10 or more prism diopters (PD), at either near or distance in the primary position, that decreased by 10 or more PD with the use of full hyperopic correction were included. The angle of deviation was primarily determined by the prism and alternate cover technique at both distance and near, although some infants and young children were measured by the Hirschberg or modified Krimsky techniques at near. A cycloplegic refraction was obtained in all patients with a majority using 1% cyclopentolate approximately 30 minutes before retinoscopy.

Fully accommodative esotropia was defined as those patients with ≤ 8 PD of deviation after wearing their full hyperopic spectacle correction for a 4-week period. Similarly treated patients with ≥ 10 PD of residual esodeviation were designated as having PAET. Fully accommodative esotropia that decompensated (developing ≥ 10 PD of esotropia) was distinguished from PAET by maintaining ≤ 8 PD of esodeviation with spectacle correction for a period of at least 1 year. Surgical intervention was at the discretion of the provider with parental consent.

Continuous data are presented as a mean with the range, and categorical data are presented as counts and percentages. Comparisons between groups for continuous variables were completed using Wilcoxon rank-sum tests, whereas comparisons between groups for categorical variables were analyzed by Fisher exact tests. All statistical tests were 2-sided, and the threshold of significance was set at $\alpha=0.05$. The cumulative probability of patients' ability to discontinue the use of spectacles was calculated using the Kaplan–Meier method.

Results

A total of 306 pediatric residents of Olmsted County, Minnesota, were newly diagnosed with accommodative esotropia during the 20-year study period. The historical and initial clinical characteristics of the 306 patients combined and divided into the 2 main forms of esotropia are shown in Table 1. Eighty percent (244) had FAET, and 20% (62) had PAET. The mean age at diagnosis for all 306 patients was 4 years (range 2.2 months to 18.6 years), and one third presented with amblyopia. Sixty-five (21.2%) of the 306

patients had a high accommodative-convergence/accommodation ratio, defined as an esodeviation of 10 PD or more at near compared with distance. Children with FAET had an older age at onset ($P = 0.015$) and diagnosis ($P = 0.026$), a smaller angle of deviation at both distance ($P < 0.001$) and near ($P < 0.001$), and greater hyperopia ($P = 0.002$) than those with PAET.

The mean follow-up for the 306 children was 9.8 years (range, 0–27.9 years). Hypermetropia decreased from an initial mean of +3.8 diopters to +2.8 diopters at final follow-up, representing an average 0.1 diopter decline per year of follow-up. For those children (221) with 5 years or more of follow-up, 68 (30.8%) no longer needed spectacle correction for strabismus at a mean age of 12.0 years (range, 2–27.7 years). The Kaplan–Meier rate of discontinuing the use of spectacles to control distance esotropia in this population is shown in Figure 1. Eight percent of children were spectacle-free by 5 years after diagnosis, 20% were spectacle-free by 10 years, and 37% were spectacle-free by 20 years. Table 2 shows those factors associated with the discontinuation of spectacles, with those with lower initial hyperopic error ($P < 0.001$)

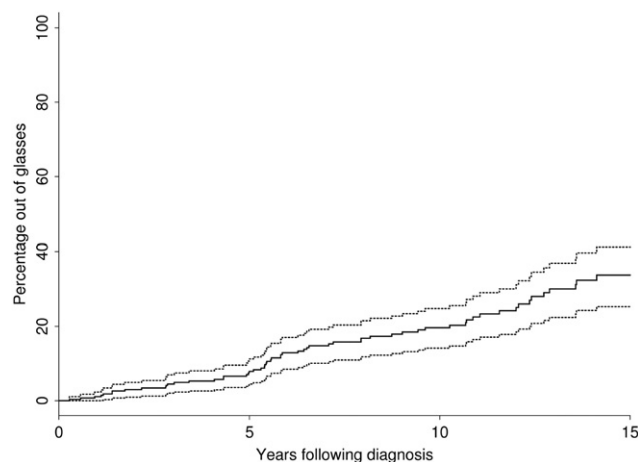


Figure 1. Kaplan–Meier curve estimating elimination of spectacle use in children with accommodative esotropia.

Table 2. Clinical Factors Associated with Discontinuation of Spectacles among 306 Children Diagnosed with Accommodative Esotropia in Olmsted County from 1975 to 1994

	Out of Spectacles		P Value
	No N = 229	Yes N = 77	
Age at diagnosis (yrs)	4±2.7	4.3±2.1	0.12
Age at onset (yrs)	2.9±1.6	3.4±2.3	0.23
Initial mean (D) refraction	+4±1.8	+2.87±1.1	<0.001
Initial deviation in PD at near	25.2±12.5	24.3±13.7	0.33
Initial deviation in PD at distance	19.4±12.9	18.1±13.0	0.39
Premature birth	15 (7.7%)	0 (0%)	0.046
Inferior oblique dysfunction	17 (6.9%)	6 (10%)	0.46
Amblyopia	81 (35.8%)	13 (23.2%)	0.082

D = diopter; FAET = fully accommodative esotropia; PAET = partially accommodative esotropia; PD = prism diopter. P values were obtained for the comparison of FAET with PAET using the Fisher exact test (categorical variables) or Wilcoxon rank-sum test (continuous variables).

and full-term birth (*P* = 0.046) having a higher likelihood of becoming spectacle-free.

During the approximate 10-year follow-up period, 33 (13.5%) of the 244 children with FAET eventually required strabismus surgery. The clinical characteristics of these 33 children compared with the 211 children with FAET who did not undergo surgery are shown in Table 3. Children requiring surgery for a decompensation of their deviation were more likely to be male (*P* = 0.039) and had a significantly earlier age of onset (*P* = 0.008) and age at diagnosis (*P* < 0.001). Among the 62 children with PAET, 47 (75.8%) underwent surgery, whereas the remaining 15 patients with PAET were lost to follow-up or their guardians refused surgery. A second surgery was necessary to maintain alignment in 7 (21%) of the patients with FAET compared with 12 (26%) of the 47 children with PAET (*P* = 0.79).

Discussion

This study describes the surgical management and likelihood of discontinuing glasses for esotropia in a population-based cohort of 306 children with accommodative esotropia. The Kaplan–Meier rate of discontinuing glasses was 8% at 5 years and 37% at 20 years. Full-term birth and low hyperopic error were associated with the early discontinuation of glasses. Surgical intervention for decompensated FAET, more likely in boys and in those with an earlier age at onset and diagnosis, was necessary in a minority of patients.

Although the findings of this study are consistent with the results of Swan,⁶ Raab and Spierer,¹⁰ and Black,⁴ who reported a minority of patients discontinuing spectacle use for strabismus (2.5%–24.4%), this study reports a relatively higher percentage of patients who were able to discontinue glasses for distance esotropia.^{4–7,10} From the Kaplan–Meier curve seen in Figure 1, 20% and 34% of patients were able to eliminate spectacle use by 10 and 15 years after diagnosis, respectively. Black⁴ found that 13% of patients (37/285) discontinued spectacle use for esotropia at a mean age of 11.6 years (range, 7–17) during a mean follow-up of only 1.9 years. Rutstein and Marsh-Tootle⁵ reported similar findings with 5 of 39 patients (12.8%) who were orthotropic without glasses with an average follow up of 9.5 years. Swan⁶ reported a persistent need for hyperopic correction in 38 of 39 patients followed into early adulthood. Mulvihill et al⁷ reported that none of their 103 patients with accommodative esotropia were able to maintain alignment without spectacles after a mean follow-up of 4.5 years (range, 2–9.5 years). They reported a relatively stable hyperopic refractive error over the years of their study; therefore, none of their patients were able to discontinue use of their glasses. Although previous studies are limited by relatively small sample sizes or shorter follow-up periods, the current study is

Table 3. Factors Associated with Requiring Strabismus Surgery in Olmsted County Patients Aged <19 Years with a Diagnosis of Fully Accommodative Esotropia

	FAET without Surgery N = 211	FAET with Surgery N = 33	P Value
Male gender	104 (49%)	23 (70%)	0.039
Family history	61 (40%)	11 (50%)	0.49
Prematurity	11 (7%)	0 (0%)	0.37
Mean birth weight (range)	3420 (1030–4852)	3408 (1640–4490)	0.93
Mean age of onset in yrs (range)	3.3 (0–12.5)	2.1 (0–4.7)	0.008
Mean age at diagnosis in yrs (range)	4.3 (0.2–18.6)	2.9 (0.5–7.1)	<0.001
Amblyopia (%)	67 (35%)	5 (17%)	0.087
Mean angle deviation in PD at distance (range)	17.5 (0–70)	16.4 (0–40)	0.67
Mean angle deviation in PD at near (range)	23.2 (0–60)	23.4 (0–40)	0.73
Inferior oblique dysfunction (%)	16 (8%)	3 (9%)	0.37
Dissociated vertical divergence (%)	1 (<1%)	1 (3%)	0.25
Mean cycloplegic refraction (min, max)	+3.98 (–3.00 to +8.50)	+3.55 (+1.13 to +8.75)	0.099

FAET = fully accommodative esotropia; PAET = partially accommodative esotropia; PD = prism diopters. Categorical variables are reported using number (percent), and P values result from Fisher exact test. Continuous variables are reported using mean (min – max), and P values result from a Wilcoxon rank-sum test.

more consistent with those reports demonstrating that some patients will be free from spectacles by early adulthood.

Factors associated with the discontinuation of spectacles for distance esotropia in this study included lower initial hyperopic error ($P < 0.001$) and full-term birth ($P = 0.046$). Black⁴ also noted that children with a lower initial degree of hypermetropia were more likely to experience a resolution of their esotropia. In this study, hypermetropia declined from an average of +3.8 diopters at diagnosis to +2.8 diopters at final presentation over a mean follow-up of 9.8 years, representing a mean decline of 0.1 diopters per year. This decrease is in light of the general increase of hypermetropia, on average, to age 7 years, followed by a progressive decline thereafter.¹²⁻¹⁴ Much debate exists concerning the amount of correction appropriate for the treatment of accommodative esotropia. Some investigators have argued that correcting the full hyperopia may inhibit emmetropization, therefore prolonging time in glasses and delaying the resolution of esotropia.^{15,16} Lambert et al¹⁵ provided data demonstrating that a reduction in hyperopic correction aided in the discontinuation of spectacle use in 91% of patients with FAET who had 3 diopters or less of correction. Prescribing the full hyperopic correction was the usual practice at the Mayo Clinic, and this study reported a higher rate of discontinuing spectacles than previous studies.

Thirty-three (13.5%) of the 244 children with FAET eventually required strabismus surgery and represent those who developed ≥ 10 PD of esotropia in their full hyperopic correction 1 year or more after their initial diagnosis. Reported rates of decompensation in the literature ranged from 2.4% to 50%; however, our rate was consistent with most studies.^{4,7,17-21} In fact, Black⁴ reported a Kaplan-Meier rate of 19% deterioration requiring strabismus surgery at 18 years after the initiation of treatment. In this study, the subsequent need for surgery among children with FAET was greater among boys ($P = 0.039$) and in those with an earlier age at onset ($P = 0.008$) and diagnosis ($P < 0.001$). Black⁴ also found that a younger age at diagnosis was associated with decompensation, as well as oblique muscle dysfunction and an abnormal distance-near relationship. Early onset, especially in patients less than 1 year of age, seems to be associated with deterioration of FAET.^{4,17}

Study Limitations

There are several limitations to the findings in this study. Not all esodeviations are significant enough to be observed by parents or caregivers, thereby avoiding detection and the subsequent examination by an ophthalmologist in Olmsted County. This weakness is more likely to overlook smaller angles of deviation and corresponding lower amounts of hypermetropia, thereby potentially underestimating the rate of discontinuing glasses. Another limitation is that some patients may have obtained care outside of Mayo Clinic and Olmsted Medical Group, although the relative geographic isolation from major urban centers makes this occurrence rare. In addition, the retrospective design is limited by nonstandardized data and incomplete follow-up. For example, the study patients were managed by a variety of clinicians within the department, including resident and general

ophthalmologists, which may have introduced more errors of measurement than studies performed exclusively by strabismus specialists. Finally, the ethnic constraints of the population further limit the findings. Because the ethnic composition of Olmsted County was 95% white during the years of study, our results are best extrapolated to other semiurban white populations of the United States.

In conclusion, the majority of children in this population-based cohort of 306 patients with accommodative esotropia continued to require spectacle correction into their second decade of life. Approximately one third of the study patients were spectacle-free by 15 years after their initial diagnosis. Lower initial hyperopic error and full-term birth were associated with an increased likelihood of eliminating spectacle correction for distance esotropia. A minority of patients with FAET eventually decompensated, more often boys and those with an earlier age at onset and diagnosis, and required surgical intervention.

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